l. X.—No. 46.] [MARCH, 1893.

THE MINERALOGICAL MAGAZINE AND JOURNAL OF THE Mineralogical Society.

INSTITUTED 3rd FEBRUARY, 1876.

EDITED BY H. A. MIERS, M.A.,

ASSISTED BY A COMMITTEE OF COUNCIL.

Reprinted 1964 for Wm. Dawson & Sons Ltd., London
with the permission of
THE MINERALOGICAL SOCIETY

Mineralogical Society.

OFFICERS AND COUNCIL FOR 1892-93.

PRESIDENT.

PROFESSOR N. S. MASKELYNE, M.A., F.R.S.

PAST-PRESIDENTS.

H. C. SORBY, LL.D., F.R.S. 1876–1879.
PROF. M. F. HEDDLE, M.D., F.R.S.E. 1879–1881.
W. H. HUDLESTON, M.A., F.R.S. 1881–1883.
REV. PROF. T. G. BONNEY, D.Sc., F.R.S. 1883–1885.
L. FLETCHER, M.A., F.R.S., 1885-1888.
R. H. SCOTT, M.A., F.R.S., 1888-1891.

VICE-PRESIDENTS.

REV. PROF. S. HAUGHTON, M.D., F.R.S.
HUGO MÜLLER, Ph.D., F.R.S.

TREASURER.

F. W. RUDLER, F.G.S.

GENERAL SECRETARY.

L. FLETCHER, M.A., F.R.S., 36 Woodville Road, Ealing

FOREIGN SECRETARY.

PROF. J. W. JUDD, F.R.S.

PROF. GRENVILLE COLE, F.G.S.
T. W. DANBY, M.A., F.G.S.
JOHN HORNE, F.R.S.E., F.G.S.
FRANK RUTLEY, F.G.S.
REV. H. P. GURNEY, M.A., F.G.S.
PROF. G. D. LIVEING, M.A., F.R.S.
LIEUT.-GEN. C. A. McMAHON, F.G.S.
J. J. H. TEALL, M.A., F.
PROF. A. H. CHURCH, M.A.
PROF. G. LE NEVE F
D.Sc., F.R.S.
H. A. MIERS, F.G.S.
PROF. W. I. MACADAM

TRUSTEES.

PATRICK DUDGEON, F.R.S.E.
PROF. N. S. MASKELYNE, F.R.S.

AUDITORS

B. KITTO, F.G.S.
F. RUTLEY, F.G.S

LIBRARIAN.

PROFESSOR W. J. LEWIS, M.A., F.C.S., The New Museums, Ca

(to whom all publications intended for the Library of the Soci
should be forwarded)

EXCERPT MINUTES OF COUNCIL MEETING.

ld in the Apartments of the Geological Society, June 14th, 1892.

Prof. Story-Maskelyne, F.R.S., President, in the Chair.

olved that there is no general objection to the election of ladies to embership of the Society.

olved to nominate Prof. Judd, Prof. Church, Prof. Le Neve Foster Ir. Miers as candidates for the Council, in place of the retiring ers, Prof. Green, Prof. Lewis, Mr. Dudgeon and Mr. Harker.

GENERAL MEETING.

ld in the Apartments of the Geological Society, June 14th, 1892.

Prof. Story-Maskelyne, F.R.S., President, in the Chair.

een Members and one visitor were present.

following papers were read :—

Note on the rare development of a crystal of tourmaline from : by Prof. Lewis. (Page 142.)

On pilolite from Devon and Mexico: and on a new copper sili- rom Egypt: by Mr. Prior.

On a peculiar occurrence of Galena: by Mr. J. S. Thomson. 148.)

Description of a new mineral, Geikielite: by Mr. Allan Dick. nunicated by Mr. Teall.) (Page 145.)

Notes on various museums of Scandinavia, Russia and Germany: . Miers.

cimens in illustration of the papers of Mr. Prior, Mr. Thomson and ick were exhibited.

EXCERPT MINUTES OF COUNCIL MEETING.

d in the Apartments of the Geological Society, October 25th, 1892.

Dr. Hugo Müller, F.R.S., Vice-President, in the Chair.

resignation of Mr. J. H. Hampton, Ordinary Member, was an- ed.

The following dates of Meeting were approved for the year 1893:- January 17, April 18, June 13, October 24; the latter to be the Ann versary Meeting.

The draft Annual Report of Council submitted by the Secretary w read and approved.

ANNIVERSARY MEETING.

Held in the Apartments of the Geological Society, October 25th, 1892.

Dr. Hugo Müller, F.R.S., Vice-President, in the Chair.

Sixteen Members and two visitors were present.

The following Report of Council for the Session 1891-2 was read a approved : —

REPORT.

The Balance Sheet for the year ending December 31st, 189 which was issued with Number 45 of the Journal, showed that t state of finances was not unsatisfactory : the Assets (exclusive the Stock of the Journal and Library) amounting to £201 2s. 9 in excess of the Liabilities. In this connection it may mentioned that the number of Members who had compound before December 31st, 1891, for their Annual Subscription w 31.

During the session 1891-2, two Ordinary Members have be elected and one Ordinary Member has resigned. Four meetin have been held, all in London, and (by kind permission) in t Apartments of the Geological Society, Burlington House.

Two Numbers of the Journal (44 and 45) have been issu since the last Anniversary Meeting. Of these No. 44 was unusual extent : it comprised a paper by Mr. Rutley giving t results of a very prolonged study of the forms of crystallites ; paper by Professor Grenville Cole calling attention to the way which devitrification of a cracked obsidian may simulate in results an axiolitic growth : a description of an alumin serpentine from Kynance Cove by Mr. Fox : a notice of

currence of sapphire in Scotland, and an account of the optical operties of gyrolite, both by Professor Heddle : a note on occurrence of melanterite by Dr. Irving ; and descriptions tysonite, bastnäsite, meteoric iron, anatase and sapphire by r. Kunz. The greater part of the Number is occupied by e Secretary's paper on the Transmission of Light in ystals, a subject which only comes within our province by ason of the fusion of the Mineralogical and Crystallological cieties, and at first sight would seem beyond the proper limits the *Mineralogical Magazine*. The paper attempts to provide a w mode of treatment of the optical problems presented by ystals : the method at present in use is based on mechanical sumptions, the truth of which has never been generally accepted, d the incorrectness of which is now fully established : if the tical elasticity of crystals is really the same for all directions, according to the latest version of the elastic theory is the case, is clearly unsatisfactory to continue a mode of treatment of uble refraction which is based on variation of elasticity with rection. Whether or not this paper affords a satisfactory lution of the difficulty is another matter, and the question must decided by the practical experience of the teachers of the sub-t. We may add that the author defrayed the cost of illustration the paper, and did not receive the usual grant of separate pies.

Number 45 was largely occupied by the index to the ineralogical and Petrographical Papers of 1888, the result of uch patient labour on the part of Mr. Miers and Mr. Prior, to hom the hearty thanks of the Society are due: the same umber contained a paper by Mr. Solly, descriptive of the inerals from the apatite-bearing veins on the south-east coast Norway, and a note on their occurrence by Mr. A. L. Collins : e results of an examination of the pinite of Breage by Mr. J. H. llins : mineralogical notes from Torreon in Mexico by Mr. H. Collins : the announcement of the occurrence of gigantic ystals of danalite in Cornwall by Mr. Miers and Mr. Prior : e first description of the optical characters of orpiment by Mr. iers ; notes on crystals of manganite by Mr. Rutley ; and on netland aragonite by Mr. J. S. Thomson.

On the motion of the Chairman, seconded by Mr. Miers, the Report Council was adopted.

The Scrutineers reported that 39 voting papers had been returne and that the following list of Officers and Council were unanimously a proved:—

President.	Prof. Story-Maskelyne, M.A., F.R.S.
Vice-Presidents.	Rev. Prof. S. Haughton, M.D., F.R.S. Dr. Hugo Müller, Ph.D., F.R.S.
Treasurer.	Mr. F. W. Rudler, F.G.S.
General Secretary.	Mr. L. Fletcher, M.A., F.R.S.
Foreign Secretary.	Mr. T. Davies, F.G.S.
Ordinary Members of Council.	Prof. Grenville Cole, F.G.S. Mr. T. W. Danby, M.A., F.G.S. Mr. John Horne, F.R.S.E., F.G.S. Mr. Frank Rutley, F.G.S. Rev. H. P. Gurney, M.A., F.G.S. Prof. G. D. Liveing, M.A., F.R.S. Lieut.-Gen. C. A. McMahon, F.G.S. Mr. J. J. H. Teall, M.A., F.R.S. Prof. A. H. Church, M.A., F.R.S. Prof. C. Le Neve Foster, D.Sc., F.R.S. Prof. J. W. Judd, F.R.S. Mr. H. A. Miers, M.A., F.G.S.

A vote of thanks to the auditors (Mr. Kitto and Mr. Rutley) passed, and the auditors were re-elected.

Votes of thanks were also passed to the retiring Members of Cou (Mr. Dudgeon, Prof. Green, Mr. Harker, Prof. Lewis), and to Geological Society for the use of its Apartments.

The following papers were then read:—

1. On Binnite from the Binnenthal: by Dr. Trechmann.

2. On a new form of Descloizite from the Argentine, and on crys lised native zirconia (Baddeleyite), a new mineral from Ceylon: by Fletcher. (Page 148.)

3. On Spinels from iron-slag: by Mr. Allan Dick (communicated Mr. Teall.)

4. On Selenite from Herne Bay : by Mr. Rutley.

5. Preliminary notes on Xanthoconite and Rittingerite : by Mr. iers and Mr. Prior.

6. A locality of Cerium minerals in Cornwall : by Mr. Miers.

Professor Judd exhibited some excellent photographs of quartz, as ex- nined in polarised light, and Mr. Rutley a large series of optical models : ecimens illustrative of the various papers were exhibited by the thors.

EXCERPT MINUTES OF COUNCIL MEETING.

Held in the Apartments of the Geological Society, January 17th, 1893.

Prof. Story-Maskelyne, F.R.S., President, in the Chair.

The audited Balance Sheet for the year 1892 was submitted and proved, and ordered to be issued with the next Number of the Journal age xiii).

Mr. George Barrow, Geological Survey of Scotland, was elected an rdinary Member of the Society.

The death of Mr. Thomas Davies, F.G.S., Foreign Secretary, was nnounced.

It was resolved to initiate a "Thomas Davies Memorial Fund" for the nefit of the widow and children, and an Executive Committee, with rofessor Story-Maskelyne as Chairman, Dr. Hugo Müller as Treasurer, r. Miers as Secretary, was nominated.

Professor J. W. Judd, F.R.S., was elected Foreign Secretary, and rofessor W. I. Macadam, F.C.S., an Ordinary Member of Council, by o-optation.

GENERAL MEETING.

Held in the Apartments of the Geological Society, January 17th, 189

Prof. Story-Maskelyne, F.R.S., President, in the Chair.

Eight Members were present.

The election of Mr. George Barrow as Ordinary Member of the Societ the death of Mr. Thomas Davies; the initiation of a "Thomas Dav Memorial Fund;" the election of Professor Judd as Foreign Secret and of Professor Macadam as Ordinary Member of Council, were announc

The Secretary read an obituary notice of Mr. Davies.

The following papers were read:—

1. On a discovery of "Oriental Ruby" and Margarite in the Provi of Westland, New Zealand: by Prof. G. F. Ulrich, F.G.S.: communica by Prof. Judd.

2. On the Isomorphism of the Red-silvers: by Mr. Miers.

3. On a discovery of Native Zirconia in Brazil: by Mr. Fletcher.

Specimens were shown in illustration of Professor Ulrich's paper.

RECEIPTS.

	£	s.	d.
Balance from year 1891	8	16	7
Subscriptions:—(1) in advance	2	7	0
,, (2) current	58	0	0
,, (3) in arrear	6	6	0
Entrance Fees and Compositions	22	1	0
Sale of Journal	13	4	6
Dividends on Stock	7	5	2
	£118	0	3

PAYMENTS.

	£	s.	d.
Printing and Stationery	78	16	0
Illustrations	4	12	0
Attendance at Meetings	0	10	0
Editorial and Clerical Expenses	Nil		
Postages and Parcels	3	19	2
Investments and Commission	7	4	5
Bank Commission on Cheques	0	1	7
Balance	22	17	1
	£118	0	3

Examined and compared with the vouchers and found correct. (Signed)

BENEDICT KITTO, } *Auditors.*
FRANK RUTLEY, }

January 16th, 1893.

LIABILITIES.

	£	s.	d.
Printing and Stationery	50	0	5
Illustrations	2	3	0
Attendance at Meetings	1	1	0
Received in advance (1) Subscriptions	2	7	0
,, ,, (2) Sale of Journal	0	5	6
Editorial Postage	0	8	8
Excess of Assets over Liabilities	274	15	7
	£331	1	2

The number of Life Members on December 31st, 1892, was 33.

ASSETS.

	£	s.	d.
Balance as above	22	17	1
Subscriptions for 1890-2 unpaid	8	8	0
Stock in 2¾ per Cent. £272 14s. 5d. at 98	267	5	4
Interest on Stock (unpaid)	1	16	4
Sale of Journal:—(1) due from Publishers...	19	13	0
,, ,, (2) due on Office Account	3	13	5
Due for extra Authors' Copies	7	8	0
	£331	1	2

The Stock of Publications and the Library are not included in the above assets.

(Signed)

L. FLETCHER,

General Secretary.

Digitized by the Internet Archive
in 2023

https://archive.org/details/mineralogical-magazine_1893-03_10_46

THE MINERALOGICAL MAGAZINE
AND
JOURNAL
OF THE
MINERALOGICAL SOCIETY.

No. 46. MARCH, 1893. Vol. X.

Notes on the Micro-chemical Analysis of Rock-making Minerals.

By Lieutenant General C. A. McMahon, F.G.S.

[Read April 12th, 1892.]

Part 1.—General Remarks.

ALL petrologists who have worked much with the microscope must have felt the want of a system of micro-chemical analysis at once simple and reliable. Having devoted some time to the study of micro-chemical reactions, I think it may save the time and labour of students who propose to take up the subject if I give them the result of the experience I have refined up to date.

In order to shorten this paper as far as possible, I have limited myself to the bases that commonly enter into the composition of rock-making minerals, and have excluded those which relate to ores.

Micro-chemical analysis is not only an essential adjunct to micro-petrological research, but it is capable of rendering some aid to the ordinary chemist. Not only does it afford a ready means of testing precipitates, but it is even more essential as a method for testing the purity of reagents. Until I took up this inquiry I had no idea of the *extent* to which the

reagents supplied by some good firms contain chemical impurities. I w
astonished to find, for instance, that my bichloride of platinum invariab
showed the presence of potash in every mineral I tested with it; that n
fluosilicic acid always indicated the existence of an appreciable amount
soda; and my aluminium sulphate, delusively labelled "purified," co
tained so much potash that it crystallised on my glass slides as an alu
I mention these cases as mere illustrations. I have succeeded in obtai
ing some chemicals sufficiently pure to work with; but in other case
have failed to do so. Pure uranium acetate, for instance, is said
belong to the rhombic system and to crystallise in long prisms; b
though I have had uranium acetate specially made for me, all tha
have obtained crystallises in the cubic system in forms identical w
those of the double salt of acetate of sodium and uranium. As a test
soda, therefore, by the microscopic method, it is worse than useless.

In micro-chemical analysis I have found the following system the m
convenient to pursue. I convert the bases present in the minerals un
examination into sulphates,[1] and, with one or two exceptions to be no
further on, work with these sulphates in aqueous solution without the
of heat. There is considerable advantage, it seems to me, in worki
with salts in the form of sulphates; most of them are soluble in wat
they are all insoluble in absolute alcohol, and Canada balsam dilu
with benzole or chloroform does not corrode them. Scarcely any
those entered in Part II. are deliquescent; whilst the alums are the o
ones that crystallise in the cubic system.

All the sulphates can be mounted in Canada balsam with the great
ease and preserved for any number of years for future study.
microscopist therefore can dispense with the aid of figured illustratio
he can form, what is far better, an imperishable collection of typ
specimens of the salts themselves to be always at hand for ready referer

Other salts besides the sulphates can be mounted in Canada bals

---

[1] Silicates, insoluble in sulphuric but soluble in hydrofluoric acid, I convert
sulphates by dissolving them in a state of fine powder in hydrofluoric acid
platinum vessel with the aid of heat. I then add sufficient sulphuric acid to
vert the bases into sulphates. On evaporation to dryness the silica is driven o
the form of fluosilicic acid and the sulphates are left behind. These can no
dissolved in water, or, in the case of barium or strontium, in hot sulphuric
A similar process can be used to test the purity of the hydrofluoric acid emplo
viz. add concentrated sulphuric acid to the HF aq. and evaporate to dryness.
the HF contains bases in any appreciable quantity they will be left behin
sulphates and may be detected under the microscope. In the case of mineral
soluble in hydrofluoric acid they must be decomposed by fusion with carbona
soda or some other flux. See Zircon, Part III.

ut the mounting and preservation of some of them are extremely difficult. Many of the chlorides, for instance, deliquesce, rendering the use of heat n some form necessary; many are corroded by Canada balsam; and many crystallise in the cubic system, rendering their identification more difficult. Potassium chloride, for instance, cannot be distinguished from odium chloride under the microscope.

Having obtained a solution of a sulphate, or a mixture of sulphates, I lace a drop of the solution on a glass slide and allow it to evaporate pontaneously in a place free from wind, draught or dust. I find a shelf n a glass book-case a suitable place. Five or six slides should be prepared at the same time. The next day two or three of the most perfect f these should be selected for mounting, but it is material to preserve an nmounted specimen for subsequent comparison with the mounted ones. he unmounted slide enables us to observe whether the salt effloresces, eliquesces, becomes opalescent, or has a silky lustre. Information regarding its refraction can also be obtained, for salts, like gypsum, whose ndex of refraction is very close to that of balsam will, when mounted in hat medium, become invisible, or nearly so, in ordinary transmitted light.

The material I use for mounting is Canada balsam diluted with hloroform until it flows freely. I keep it in a small stoppered bottle, and nd one of about half an oz. capacity very convenient. I pour this alsam very carefully, drop by drop, on the crystals to be mounted, lace a thin cover glass over the balsam and allow the latter to consolidate by the spontaneous evaporation of the chloroform without subecting the preparation to pressure or heat. From one to three days is fficient, in ordinary cases, for the consolidation of the balsam.

I have found it convenient to divide this paper into three parts. The resent part (Part I.) is devoted to remarks of an explanatory character. art II. contains, in a tabular form, a list of sulphates with the most mportant or best known of their hydrates and double salts. It contains hemical information gleaned from various standard works on chemistry. he optical system to which each salt belongs, and its chemical formula, re given in cols. 1 and 4 on the authority of either Fock[1] or Roscoe and chorlemmer.[2] Col. 5 indicates the form in which the salt appears when rystallised on a glass slide by the method above described, and embodies every case the result of my own observations.

The forms described in col. 5 will not be found to agree, in every case,

---

[1] *Krystallographisch-Chemische Tabellen*, 1890.

[2] *A Treatise on Chemistry*, Vol. II. The Metals. New Edn.

with the crystals figured in mineralogical or ordinary chemical work The crystals figured in such works are often natural minerals formed i the laboratory of nature under conditions that cannot be reproduced b the micro-chemical student; in other cases they are typical examples exceptionally perfect crystals selected from a large number obtained b the crystallisation of a considerable quantity of material from saturate solutions. For our purposes we must be content with the results that ca be obtained by allowing a drop of an aqueous solution to crystallise on glass slide by spontaneous evaporation. The conditions under whi crystallisation takes place in the latter case differ from those whi obtain in the cases above referred to, and the results are therefo sometimes considerably modified. The material at the disposal of th microscopist is often extremely small, and his methods, to be of any valu must be capable of dealing with small quantities.

Cols. 6, 7 and 8 contain optical observations for which I am respo sible. Cols. 6 and 7 require a few words of explanation. I have giv the order of colours exhibited by the crystals according to Newto scale,[1] as I think this affords a rough mode of determining the doub refraction of these salts which is of some practical value. Colours, doubt, depend not only on the strength of the double refraction, and t direction taken by the light in its passage through a crystal, but also the thickness of the crystal. But in dealing with the results of t spontaneous evaporation of an aqueous solution on a glass slide I thi it will be generally found that each salt has a habit of its own in respect the general size and general thickness of its crystals as well as the faces on which they commonly lie, and that therefore they w generally yield fairly similar results as regards colours in polarised ligh It will be found that whilst certain salts habitually yield colours as hi as the 7th order, others never give colours higher than those of the 1 2nd or 3rd order, as the case may be. By discarding from co sideration specially thin and attenuated crystals deposited when nea the whole of the material in the drop had been exhausted, and by sele ing for observation the crystals that exhibit the strongest double refracti we obtain data of some value. Treated in this way the colours affor rough practical guide to aid us in determining the identity of the s The order of colour recorded in Col. 6 is the maximum observed by me

In Col. 7 the direction of the major axis of elasticity has been det

[1] For the mode of ascertaining the order see my paper on Double Refractio Minerals, *Geol. Mag.* 1888, p. 548. Also p. 65 of *Rosenbusch's Microscopical Phy graphy*, by Iddings.

ined with the aid of the quartz wedge. When it is said to be "|| to *e*" it intended to imply that when the axis of the quartz wedge is parallel to e axis of elongation of the crystal the phenomenon of *thinning* is pro-ced. I have employed $(e)^1$ as an abbreviation for the ordinary direction elongation because it excludes any pretence of absolute precision. me salts habitually lie on one face on the glass slide and are elongated one direction. In practice I find the direction of the major axis, as dicated in Col. 7, an aid to the determination of salts of great practical lue.

In Col. 8 I have alluded to a phenomenon observed when the polariser used without the analyser which is usually attributed to "absorption." lcite, and some other colourless minerals, when examined in trans-itted light with the polariser alone, exhibit dark lines, shadows and rk markings, in a certain position of the polariser (or when the lariser is rapidly revolved) which disappear altogether when the plane vibration of the nicol is altered relatively to the plane of vibration of e light passing through the mineral. Some salts possess this property a high degree—others in a much less degree or not at all. When a lourless salt, or mineral, possesses this absorption conspicuously it marks off from other minerals that do not display the property. We have e therefore a mode of distinguishing colourless minerals from one other which I have endeavoured to utilise in Col. 8.

In a previous page I assumed that we had reduced the chemical nstituents of a mineral to the form of soluble sulphates, and had ystallised a mixture of these sulphates on glass slides for microscopic amination. An inspection of these slides, with the information con-ined in Part II. before us, will often give us important information garding the character of the mineral under examination. For instance, we have treated a piece of serpentine in the manner described it will be once seen that the principal chemical constituent of the mineral is agnesia, for unmistakable crystals of magnesium sulphate will occupy prominent position on the slide. But supposing that we wish to con-m this determination, or to ascertain what other sulphates are contained our solution, we can pass on to the reactions based on Part II., or to ose detailed in Part III.

The double sulphates, recorded in Part II., supply us with a valuable eans of detecting the presence of many metallic salts. Suppose, for tance, that we are seeking for evidence of the presence of sodium, we

---

[1] I have occasionally given *c* when the vertical crystallographic axis is intended.

examine our original slides to see whether they contain any cubi crystals of alum. If they do not do so there is a strong probability tha the mineral under examination does not contain either aluminium c chromium as well as sodium. We then place a few drops of the origina aqueous solution on several glass slides and add two or three drops of a aqueous solution of aluminium sulphate to some of the slides, and tw or three of chromic sulphate to the other slides, and allow these t evaporate spontaneously without the application of heat. If soda b present in the mineral crystals of alum will be found on the slides.

Then we can further test for soda (without going beyond methods base on Part II.) by employing, in the way described, the sulphates of calcium magnesium or manganese, with each of which sodium sulphate form double salts.

The above illustration refers to the detection of sodium only, but reference to Part II. will show that the sulphates of many other meta may be detected by the employment of sulphates that form double sal with them. Cold solutions, combined with spontaneous evaporation, hav yielded me the best results.

In Part III. I have given some selected tests *supplementary* to thos suggested by Part II. Most of these reactions, due originally to Hau hofer, Behrens, Boricky, and others, have been taken from the works Klement and Renard,[1] and Behrens.[2] I have tried, and can recommen all the reactions entered in Part III. In one or two cases I have give my reasons for rejecting some reactions that have been suggested various authorities, but I think it unnecessary to specify my grounds f excluding other reactions which I have tried, but which, from their requirin great heat, great expertness on the part of the operator, or reagents th I could not obtain sufficiently pure, or for some other reason, were fou unsuitable for ordinary use.

In Part III. I have noted facts that seem to me of interest regardi some of the salts alluded to therein, and I will now conclude with a fe observations of more general character.

Several interesting facts will be apparent on a consideration of Part The first is that the addition of a single molecule of water to the formu of a hydrate is sufficient, in some cases, to completely alter the physi properties of the salt, involving not only a change in its optical properti and in its solubility, but in some cases even a change of colour.

---

[1] *Réactions Microchimiques*, par C. Klement et A. Renard, 1886.

[2] *Contributions to Micro-chemical Analysis*, by H. Behrens. *Chemical News*, 189

Conversely the loss of water, even when heat has not been employed, ay result in a change of molecular structure, as in the interesting in-ance noted in Part III., Iron, where a salt changes from a glass into a ystal on losing some of its water.

The formation of one hydrate rather than another depends in some ses on the temperature at which crystallisation takes place, and in others other considerations—solubility being probably a dominating factor. at is to say, as evaporation proceeds, and the volume of water present reduced, one hydrate may be thrown down first and another later on.

The student may sometimes be disconcerted by the diversity of forms esented to him by micro-chemical reactions; but fundamental diversity form in such cases is, I suspect, more often the result of minute ference in chemical composition than an instance of polymorphism. ydrates, basic salts or double salts, of which little or nothing is yet own, may be formed under special conditions. These salts reveal emselves under the microscope in forms that are new to the student, d invite him to future excursions into unexplored fields of research.

Another thing that has interested me as a student of igneous rocks is e presence in these salts of aqueous origin of twinning, zonal structure d cleavage lines.

Many kinds of twinning—penetration twins, ordinary binary twins and lysynthetic twinning, combined with macles analogous to those on the riclinc plan,—are to be found in crystals formed on glass slides in the anner above described, and they appear to be congenital in origin. hey are by no means confined to crystals formed round the margin of a op, where it might possibly be alleged that they had suffered strains om molecular tension, or from crowding; but they appear quite as mmonly in discrete crystals standing by themselves in the centre of the ea originally covered by the liquid.

The following abbreviations are used in Part II. :—

R.L.	for	right angle.
‖	,,	parallel.
e	,,	direction of elongation.
c.p.l.	,,	converging polarised light.
Q.W.	,,	quartz wedge.
C.	,,	cubic.
T.	,,	tetragonal.
H.	,,	hexagonal.
R.	,,	orthorhombic.
M.	,,	monoclinic.
Tr.	,,	triclinic.

Part II.

Table of Sulphates.

It will be convenient and will save space, to preface the Table Sulphates with the general formula of the *alums*. Omitting the selenat and mixed selenates and sulphates, the general formula is $M_2 3SO_4 . N_2 S$ $24H_2O$; where

M = Al, Cr, Mn, Fe, In or Ga; and N = Na, K, Rb, Cs, NH_4, Ag or T

The best known combinations are—.

M	with	N.
Al	,,	Na, K, NH_4, Rb, Cs, $NH_3(C_2H_5)$, Ag or Tl.
Cr	,,	Na, K or NH_4.
Mn	,,	— K or NH_4.
Fe	,,	— K or NH_4.
Ga or In	,,	— — NH_4.
M_2	,,	
CrAl	,,	— K or NH_4.

The *alums* are strictly isomorphous. They crystallise in for belonging to the cubic system, usually in cubes or octahedra, or octahedra combined with cubes.

			Sys.		Colours of.	Major Axis.	Characters.	Remarks.
ALUMINIUM.								
$Al_2(SO_4)_3$	1							
$Al_2(SO_4)_3 + 18\ H_2O$	2	Alunogen	M	(*a*) In six-sided tablets (*b*) Radiating tufts like horse tails and grasses	1st order	About 45° from *e*	Boundaries of platy crystals marked by fine dark lines	No. 2. Dissolves in two parts of water. The tablets overlap each other and form platy masses, in which six-sided micaceous crystals can be distinguished. Two angles of 92° and four of 134°. When not mounted in Canada balsam the crystals have a peculiar pearly gloss. The pearly appearance is produced by a granular salt white in reflected and opaque in transmitted light, reminding one of the beginning of kaolinisation in felspar. Query, is this one of the basic sulphates $Al_2O\ (SO_4)_2 + H_2O$, or $Al\ (OH)\ SO_4$?
Double Salts.		*See alums ante*						
BARIUM.								
$Ba\ SO_4$	3	Barytes	R	(*a*) Modified rhombic and rectangular prisms (*b*) X shaped skeleton crystals resembling ice crystals	1st order	(*a*) ‖ to *e*	(*b*) Extinguish at 45° from the arms of skeleton	No. 3. Almost insol. in H_2O (sol. 1 in 400,000). The p.p. formed by adding H_2SO_4 to an aqueous solution of a Ba salt does not yield definite crystals under the microscope. A Ba salt heated with concentrated H_2SO_4 dissolves in part, and deposits on cooling crystals of $H_2SO_4 + BaSO_4$. If exposed to moist air crystals of $H_2SO_4 + BaSO_4 + 2\ H_2O$ are deposited. See Part III.
$(Ba\ Sr)\ SO_4$	4	*See Sr.*						

	No.	Name.	System.	Form.	Double Refraction shows Colours of.	Direction of Major Axis.	Other Optical Characters.	Remarks.
BERYLLIUM.								
$BeSO_4 + 4H_2O$	5		T	(*a*) Prisms with pyramidal terminations (*b*) In radiating and star-shaped arborescent forms	7th order	(*a*) *R.L.* to *e* (*b*) || to fibres	Axial sections in *c.p.l.* cross well seen. Negative	Beryllium readily forms basic sulphates. They may be obtained by boiling the normal sulphate (No. 5) with beryllium carbonate. They form gelatinous masses. The normal salt dissolves at the ordinary temperature in its own weight of water.
$BeSO_4 + 7H_2O$	6	—	M	In prisms, sometimes twinned	3rd orde	At a high angle to *e* & to twinning plane		No. 6 separates out from an acid solution of the normal salt.
$BeSO_4 K_2SO_4 + 2H_2O$	7	—	—	Globulites either isolated or in perlitic looking base	1st order	In quadrants at *R.L.* to *Q.W.*		No. 7. The outer margins of the globulites are hard black lines. They do not possess a radiate structure. The centres are often white in reflected and brown and opaque in transmitted light. The ground-mass may be either glassy or micro-granular.
CALCIUM.								
$CaSO_4$	8	Anhydrite	R	Usually combinations of the prism, pinacoids and basal planes. Microscopic crystals often boat-	4th order. In micro-crystals, usually not higher than 2nd order.	|| to *e*	Interference fig. in *c.p.l.* is seen when prism lies on its macro-pinacoidal face	No. 8 forms when concentrated H_2SO_4 is used. With dilute H_2SO_4 No. 9 forms.

CALCIUM.								
$CaSO_4 + 2\,H_2O$	9	Gypsum	M	(*a*) Acicular prisms often in radiating groups (*b*) Swallow-tailed twins (*c*) Short prisms with rhombic outline. Acute angle about 50°. See Part III.	1st order	(*a*) About 38° from *e*, measured in direction of acute angle of rhomb	Refraction nearly the same as Canada balsam, viz, Gypsum $n=1{\cdot}52$. Balsam $n=1{\cdot}54$.	No. 9. See Part III.
$CaSO_4\,K_2SO_4 + H_2O$	10	Syngenite	M	Small tabular crystals generally showing 6 or 8 sides in outline	1st order	About 3° from (100)	No. 10 Refraction not far from balsam.	No. 10. Sol. in water 1 in 400 with separation of some gypsum. Slide shows numerous needles and prisms of gypsum with stumpy crystals of syngenite, roughly speaking resembling augite in habit. Twinning very common. Extinction between twins 15°—24°, sometimes less. Of the natural mineral Dana says it is elongated in the direction of vertical axis, and that the plane (100) always predominates.
$CaSO_4\,Na_2\,SO_4$	11	Glauberite	M	(*a*) Crystals of approximately rhombic outline with a strong rib down centre radiating like the petals of a flower (*b*) Radiating fibrous groups	(*a*) Blue of 2nd order (*b*) Double refraction feeble	(*a*) At a high angle to rib (*b*) Sometimes at high sometimes at low angle to fibre		No. 11. The crystals (*a*) have one of the acute angles pointing outwards: the other is at the centre of radiating group. The rib approximately bisects the acute angles. Many of the crystals strongly recall fig. 528 Dana's system 5th Edn. The rib is apparently the junction of $-1 : -1$ and $1 : 1$.

	No.	Name.	System.	Form.	Double Refraction shows Colours of.	Direction of Major Axis.	Other Optical Characters.	Remarks.
CERIUM.								
$Ce(SO_4)_2 + 7H_2O$	12	Ceric Sulp.	—	Reniform mass	—	—	—	No. 12 is obtained by dissolving the dioxide in dilute H_2SO_4 and evaporating in a vacuum over H_2SO_4. Ceric sulphate is decomposed by water with formation of basic salts, which vary in composition according to the quantity of water present. It forms double salts with sulphates of the alkali metals, such as $Ce(SO_4)_2 + 2K_2SO_4 + 2H_2O$ small yellow monoclinic crystals.
$Ce_2(SO_4)_3$	13	Cerous Sulp.	—	Small crystals and long needle-shaped prisms badly terminated	—	—	No. 13. Straight extinction	No. 13. Separates from a warm solution. It dissolves in 6 parts of cold and 60 parts of hot water. Also in hot H_2SO_4 which on cooling throws down small crystals and long needle-shaped prisms, which are re-dissolved after standing for some hours.
$Ce_2(SO_4)_3 + 8H_2O$	14	,,	M	Prisms terminated by clino-domes	7th order	At a very high angle to plane of twinning and to *e*	No. 14. Prisms extinguish 25° from vertical edge Some crystals exhibit absorption with single nicol	No. 14 separates from a concentrated solution. It occasionally exhibits multiple twinning.

	No.	Name.	System.	Form.	Double Refraction shows Colours of.	Direction of Major Axis.	Other Optical Properties.	Remarks.
CERIUM.								
$Ce_2(SO_4)_3 + 9H_2O$	15	Cerous Sulp.	H	(*a*) Prisms with pyrl. terminations (*b*) Radiating fibres like spherulites (*c*) Radiating tables with the habit of a zeolite	1st order	(*a*) and (*b*) at *RL* to *e* (*c*) ‖ to *e*		No. 15 separates principally from dilute solution, but generally both 14 and 15 will be found on the same slide. Sol. 1 in 6. Cerous Sulp. forms several potassium cerous double salts, as $3K_2SO_4 + Ce_2(SO_4)_3$ $Ce_2(SO_4)_3 + 2K_2SO_4 + 3H_2O$ and $Ce_2(SO_4)_3 + K_2SO_4$. Sodium and ammonium sulphates also form double salts with cerous sulphate.
COBALT.								
$CoSO_4 + 4H_2O$	16		—	A peach-blossom coloured powder				No. 16. Deposited when a concentrated solution of Co. Sulp. is passed into H_2SO_4.
$CoSO_4 + 6H_2O$	17		M	In crystals				
$CoSO_4 + 7H_2O$	18	Bieberite or Cobalt Vitriol	M	Crystalline crusts made up of obscurely shaped granular crystals, with occasional 4- or 6-sided tabular crystals	2nd order	About 30° from *e*	Dichroic. Rose pink to amber. Relief sharp	No. 18. Sol. in 24 parts of cold water. Rose colour deepens on heating; crystal becomes opaque.
$CoSO_4 K_2SO_4 + 2H_2O$	19	—	Tr					

	No.	Name.	System.	Form.	Double Refraction shows Colours of.	Direction of Major Axis.	Other Optical Properties.	Remarks.
COBALT.								
$CoSO_4.K_2SO_4 + 6H_2O$	20	—	M	Large tabular crystals with 6, 8 or more faces, 2 or more corners often truncated; edges sometimes bevelled	So high that a double *Q.W.* is sometimes required	(*a*) Within a few degrees of *R.L.* to *e* in approximately rectangular prisms (*b*) Within a few degrees of a line bisecting the acute angles in prisms of sphenic habit	Extinction in (*a*) within a few degrees of *e*, in (*b*) within a few degrees of line bisecting acute angles. Dichroic in rose pink and amber colours. Zonal structure. Twinning not uncommon	No. 20. On heating the rose coloured crystals become reddish violet. Some of the rose red crystals show a positive bisectrix.
$CoSO_4(NH_4)_2SO_4 + 6H_2O$	21	—	M	Large stumpy prisms	Some as high as 6th, but generally 3rd order	No. 21. Within about 8° of *e* in the few cases in which the crystals are elongated	No. 21. Absorption with single nicol strong	No. 21. On heating changes from rose red to violet: on cooling rose colour returns. Traces of a very oblique bisectrix, apparently positive.
CHROMIUM.								
$CrSO_4$	22	Chromous Sulp.						No. 22. Only known in solution.
$Cr_2(SO_4)_3$	23	Chromic Sulp.	—	Crystalline				No. 23. A *red* salt formed by heating No. 24 to 370°. Insol. in water, alcohol or acids.
$Cr_2(SO_4)_3 + 5H_2O$	24		—	Non-crystalline				No. 24. A *green* salt. Sol. in

	No.	Name.	Syst.	Form.	Shows Colours of.	Major Axis.	Properties.	Remarks.
CHROMIUM.								
$Cr_2(SO_4)_3 + 15H_2O$	25	Chromic Sulp.	—				Green in transmitted light	No. 25. A *violet* salt. Insol. in alcohol.
$2CrSO_4(OH)_4 + Cr_2(OH)_6 + 5H_2O$	26		—					No. 26. A basic salt.
Double Salts.								*Chromates* and *Dichromates*, see K and Na.
With Sulphates of K, Na and (NH_4)	—	*See Alums*	—	—	—	—	—	
CÆSIUM.								
Cs_2SO_4	27		R	Prisms with numerous faces	2nd order	*R.L.* to *e*		
$CsHSO_4$	28		R					
Double Salts.								
$Cs_2SO_4MgSO_4 + 6H_2O$	29	*See Mg.*	M	—	—	—	—	
With Sulp. of Al.	—	*See Alums*		—	—	—	—	
IRON.								
$FeSO_4 + 4H_2O$	30	Ferrous Sulp.	R M					$FeSO_4$ under ordinary conditions crystallises in the form of No. 32, but it takes the orthorhombic form if its supersaturated solution is touched with a crystal of zinc sulp. and the triclinic form (No. 31) if a crystal of copper sulp. is placed in a concentrated solution. When a solution of $FeSO_4$ containing free H_2SO_4 is allowed to evaporate in a vacuum, No. 32 separates first, then No. 31, and lastly No. 30. When the ferrous sulp. is exposed to the air it is changed into a compound containing ferric sulp. and ferric hydroxide, or a basic ferric sulp. $Fe_2(SO_4)_3(OH)_3$.
$FeSO_4 + 5H_2O$	31	,,	Tr					
$FeSO_4 + 7H_2O$	32	Melanterite or green vitriol	M	When evap. on slide generally in rhombs or tabular prisms	7th order	Generally ‖ to a line dividing the obtuse angle of rhomb into two unequal portions		

	No.	Name.	System.	Form.	Double Refraction shows Colours of.	Direction of Major axis.	Other Optical Properties.	Remarks.
IRON.								
$Fe_2(SO_4)_3$	33	Ferric Sulp.	—	In oval & rounded disks, often with radiating fibrous structure and in fibrous patches	1st order	‖ to axis of elongation	Extinction coincides with axis of elongation. Decided absorption with single nicol	Ferric Sulp. (No. 33) readily forms basic salts the composition of which is not positively known. It dissolves slowly in water, and is decomposed by heating into ferric oxide and sulphur trioxide. Cols. 5 to 8 is the anhydrous salt dissolved in water and re-crystallised.
$Fe_2(SO_4)_3$	34		R	Radiating needle-shaped prisms[1]	Blue of 2nd order	‖ to *e*		No. 34 is formed by adding No. 32 to boiling H_2SO_4.
$Fe_2(SO_4)_3 + 9H_2O$	35	Coquimbite	H	Prisms usually with terminal edges replaced				
$Fe_3(SO_4)_4 + 12H_2O$	36	Ferrous-ferric sulp.	M	Yellow crystals				No. 36. The two sulphates of iron form various double salts, of which this (Roemerite) is one.
FeS_2O_7	37	Ferrous disulp.	—	Green microscopic prisms				No. 37 is formed by adding iron sulp. to several times its volume of concentrated H_2SO_4. It decomposes on contact with water.
$FeSO_4(OH)_4 + Fe(OH)_6 + H_2O$	38	Vitriol Ochre	—	Massive, earthy, stalactitic				
$Fe_2(SO_4)_3 + Fe_2(SO_4)_2(OH)_2 + 10H_2O$	39	Copiapite	H ?	In six-sided crystalline scales	Red of 2nd order	‖ to *e*	Basal sections give cross on bluish ground in *c.p.l.*	

			Syst.	Form	shows Colours of.	Major Axis.	Properties.	Remarks.
IRON. *Double Salts.*								
$FeSO_4 Na_2SO_4 + 6H_2O$[1]	41		M	Globulites, spherulites and radiating fibrous crystals	2nd order	About 45° to longer axis of fibres	Sometimes has a concentric as well as radiating structure, and resembles Chalcedony	
$FeSO_4 K_2SO_4 + 6H_2O$	42		M	Large tabular crystals	7th order and higher	Variable	Absorption with single nicol, very strong	
$FeSO_4 (NH_4)_2 SO_4 + 6H_2O$	43		M	Large stout prisms variously terminated. Also in skeleton crystals	5th order	Within a few degrees of $\parallel$ to *e*	Strong absorption with single nicol. Zonal structure. *In c.p.l.* either an optic axis, or a more or less oblique bisectrix emerges	
With Sulp. of K & NH_4		*See Alum*						
POTASSIUM.								
K_2SO_4	44	Normal Sulp.	R	Flat prisms elongated in one direction: terminations various	2nd order	Generally $\parallel$, sometimes *RL* to *e*	Relief strong when mounted in balsam; when unmounted faces at angle to glass cover are black	No. 44. Sol. 1 in 10 in cold and in much smaller quantity of boiling water. Occurs in Apthitalite and Kainite. The diff. in appearance of mounted and unmounted specimens is a striking feature, and one useful for identification

[1] See Remarks, Part 3.

	No.	Name.	System.	Form.	Double Refraction shows Colours of.	Direction of Major Axis.	Other Optical Properties.	Remarks.
POTASSIUM.								
$KHSO_4$	45	Acid Sulp.	M R	(*a*) Six-sided tabular prisms (*b*) Needle-shaped ditto, also fibrous (*c*) Irregular shaped tabular crystals	6th order	Low angle to *c*	Absorption with single nicol. Mottled appearance under crossed nicols seldom extinguishing uniformly; unmounted deep black margin; strong relief; shagreened irregular surface marked with black lines. Penetration twins often seen	No. 45 occurs native in the *grotto del solfo*, near Naples, in the form of silky needles. Dissolves readily in water: is decomposed by alcohol into No. 44 & H_2SO_4. When 45 is re-crystallised from aqueous sol. No. 44 separates out first, then crystals of a salt having composition of $K_2SO_4 + KHSO_4$, and finally No. 45 crystallises out.
$K_2S_2O_7$	46	Disulphate	—	In long slender needles				No. 46 is obtained by heating No. 44 in H_2SO_4 until the mass fuses quietly. Decomposes on contact with water.
Double Salts.								
With Sulp. of Al, Cr, Mn, Fe, &c.	—	*See Alums*						
With Sulp. of Be	—	*See Be*						
,, ,, Fe	—	*See Fe*						
,, ,, Mg	—	*See Mg*						
,, ,, Mn	—	*See Mn*						
LITHIUM.								

	No.	Name.	System.	Form.	Double Refraction shows Colours of..	Direction of Major Axis.	Other Optical Properties.	Remarks.
LITHIUM.								
$Li_2SO_4 + 3H_2O$	49		H R	(*a*) 6-sided prisms, elongated in one direction; some tabular, some radiated (*b*) Stars of radiating blades	White of 7th order	*R.L.* to *e*	Some of the crystals show a negative bisectrix in *c.p.l.*, almost all of (*a*) show traces of one	
Li K SO_4	50		H	Prisms with pyramidal terminations. Sometimes basal plane truncates the pyramid	Sometimes so low as to look like an isotropic mineral, sometimes pink of 2nd order	|| to *c*	Relief good. Margins dark and sharp. Absorption with single nicol	
Li Na SO_4	51		H	Spherulitic	3rd order	Various	Relief good. Sharp dark margins Slight absorption.	Some of the spherulites have a radial structure, some have not, and others show a fixed dark cross when revolved between crossed nicols. In the former the cross is very irregular, owing to overlapping. Sometimes opaque centres. In *c.p.l.* the spherulites show traces of lemniscates.
Li NH_4SO_4	52		H	Large six-sided micaceous-looking plates	Generally very low, sometimes as high as blue of 2nd order	*R.L.* to *e*	(*n*) Cannot be far from that of Canada balsam	

	No.	Name.	System.	Form.	Double Refraction shows Colours of.	Direction of Major Axis.	Other Optical Properties.	Remarks.
LITHIUM.								
$Li\,Rb\,SO_4$	53		H	(*a*) Hexagonal tabular crystals (*b*) Rectangular four sided plates (*c*) Fibrous or stalk-like	Very feeble	*R.L.* to *e*	Outline well defined	No. 53. The hexagonal tables differ from those of $RbSO_4$. Latter are transparent, sharply outlined, and much twinned. 53 are often only translucent, never in my specimens clear or glassy.
MAGNESIUM.								
$Mg\,SO_4$	54	—	—					No. 54. When this salt is dissolved in H_2SO_4 the solution on standing deposits $MgSO_4 + H_2SO_4$ in 6 sided tables, which soon absorb moisture from the air and decompose.
$Mg\,SO_4 + H_2O$	55	Kieserite	M	In prisms, or in granular masses				No. 55. This salt is as difficult of solution in water as gypsum.
$Mg\,SO_4 + 6H_2O$	56	—	M					
$Mg\,SO_4 + 7H_2O$	57	Epsom Salt	R	(*a*) Needle-shaped prisms in radiating groups (*b*) Stout prisms	(*a*) 2nd order (*b*) Sometimes as high as 7th order	(*a*) *R.L.* to *e* (*b*) Sometimes *RL* to *e*, sometimes ‖ to *e*	Absorption with single nicol	No. 57. At the ordinary temperature 100 parts of water dissolve 125 of salt. Epsom salt on heating melts in its water of crystallisation, and loses 6 molecules of water at 150°. The last molecule is not driven off until 200° is reached. The prisms are usually 6 sided, with complex to rounded terminations. 57 (*b*) commonly contain liquid cavities with bubbles;

			Sys.	Form.	shows Colours of.	Major Axis.	Properties	Remarks.
MAGNESIUM.								
$MgSO_4Na_2SO_4 + 6H_2O$[1]	58	Blödite	M	(*a*) Crystals like primrose leaves radiating from a centre	(*a*) 1st order	(*a*) About 45° from axis of quartz wedge	Absorption with single nicol	
				(*b*) Elongated irregular shaped prisms radiating from a centre	(*b*) 7th order	(*b*) High angle to *e*		
				(*c*) Spherulitic radiating groups	(*c*) Blue of 2nd order	(*c*) About *R.L.* to *Q.W.*		
$MgSO_4K_2SO_4 + 6H_2O$	59		M	Large irregular crystals	7th order, sometimes higher	—	Absorption here and there. Internal structure often not homogeneous, giving dusty appearance	
$MgSO_4(NH_4)_2SO_4 + 6H_2O$	60		M	(*a*) Prisms with complex terminations elongated in one direction	(*a*) 3rd order	(*a*) Within 8° or 9° of ‖ to *e*	Strong absorption with single nicol zonal structure. (*a*) Extinction 5° to 8° from (*e*) In *c.p.l.* an optical axis emerges from (*a*).	No. 60. Liquid cavities with bubbles very common. Often arranged in zones.
				(*b*) Stumpy prisms, not elongated	(*b*) 7th order			
$MgSO_4Cs_2SO_4 + 6H_2O$	61		M	Large tabular crystals; shapes varied and irregular, rarely well formed prisms	Sometimes as high as 6th order	—	Absorption with single nicol	No. 61. Liquid cavities with bubbles rather numerous.

[1] I have followed Roscoe and Schorlemmer. Fock gives $4H_2O$ for this salt.

	No.	Name.	System.	Form.	Double Refraction shows Colours of.	Direction of Major Axis.	Other Optical Properties.	Remarks.
MAGNESIUM.								
$MgSO_4Rb_2SO_4 + 6H_2O$	62		M	Generally in rhombs, sometimes with two corners truncated	5th order	High angle to *e* when crystal is elongated	Absorption with single nicol	If the concentrated solution of Manganous Sulphate is allowed to evaporate *below* 6°, rhombic crystals of No. 66 are deposited. Between 7° and 20° (viz. at the ordinary temperature), crystals of No. 65 are formed. Between 20° and 30° No. 64 is deposited. (Roscoe calls them "quadratic"); at the same time a crystalline crust containing $3H_2O$ is formed. When the hydrates are heated to 200°, or their concentrated solution is boiled, the anhydrous salt $MnSO_4$ is deposited in a reddish yellow powder. It decomposes at a bright red heat. Manganous Sulp. is insol. in absolute alcohol but it removes a portion of the water from the hydrates.
MANGANESE.								
$MnSO_4 + H_2O$	63		M					
$MnSO_4 + 4H_2O$	64		R					
			M					
$MnSO_4 + 5H_2O$	65			A platy mass of felted blade-like crystals, sometimes radiated, sometimes like the shafts and barbs of a bird's wing	7th order	High angle to *e*	Strong absorption with single nicol. Some crystals show a negative bisectrix	
$MnSO_4 + 7H_2O$	66		R					
			M					
$MnSO_4Na_2SO_4 + 2H_2O$	67		?					
$MnSO_4K_2SO_4 + 2H_2O$	68		Tr					
$MnSO_4HKSO_4 + 2H_2O$	69		Tr					

	No.	Name.	System.	Form.	Double Refraction shows Colours of.	Direction of Major Axis.	Other Optical Properties.	Remarks.
MANGANESE.								
$MnSO_4Na_2SO_4 + 4H_2O$	70		M	(*a*) Almond shaped granules (*b*) Spherulitic radiating groups (*c*) Short prisms of cubic aspect	(*a*) (*b*) Pink of 2nd order	(*a*) *R.L.* to *e* (*b*) *R.L.* to axis of *Q.W.* (*c*) Uncertain		Nos. 70-73. The salts described under these Nos. are those obtained by evaporating a mixture of $MnSO_4$ with Na_2SO_4, K_2SO_4 and $(NH_4)_2SO_4$. I know of no test applicable to microscopic specimens on glass slides for determining whether the resulting double salts contain 2, 4 or 5 molecules of water
$MnSO_4K_2SO_4 + 4H_2O$	71		M	In (*a*) spherulites and (*b*) confused matted masses	Blue of 2nd order	(*a*) ‖ to axis of *Q.W.*		
$MnSO_4(NH_4)_2SO_4 + 6H_2O$	72		M	Large stumpy prisms of complex shape	3rd order	—	Strong absorption with single nicol. Refraction probably near that of balsam. Small crystals cannot be seen without polarised light	No. 72. Some crystals have well marked zonal lines. Others are so full of minute liquid and air bubbles as to present a dark dusty appearance under low powers. Many of the crystals show an optic axis in *c.p.l.*
$MnSO_4K_2SO_4 + 6H_2O$	73		M					
$Mn_2(SO_4)_3$, with Sulphates of K and NH_4		See *Alums*						
SODIUM.								
Na_2SO_4	74	Salt Cake	R					
$Na_2SO_4 + 2H_2O$	75		R					

	No.	Name.	System.	Form.	Double Refraction shows Colours of.	Direction of Major Axis.	Other Optical Properties.	Remarks.
Sodium.								
$Na_2SO_4 + 3H_2O$	76	Glauber's Salt	H R M	Short, stumpy prisms, showing many faces	Extremely feeble: from grey of 1st order to blue of 2nd order	Low angle to *e*	Crystals bordered by broad dark lines. Retraction probably high	No. 77. Glauber's Salt (mirabilite) effloresces on exposure to the air. It forms from aqueous solution between 12° and 33°. Between 33° and 40° the anhydrous salt (74) is deposited. Solubility in water is greatest at 33°, after that it declines. Between 12° a salt with 7 molecules of water forms. The anhydrous salt also forms if glauber's salt is allowed to remain exposed to the air. The anhydrous salt occurs native in thenardite and in solution in sea water, and in some springs.
$Na_2SO_4 + 10H_2O$	77							
$NaHSO_4$	78		Tr[1]	(*a*) Long blade-like prisms (*b*) In granules or stumpy prisms with many faces	Sometimes as high as 6th or 7th order	Varies greatly	Twinning not uncommon. In (*a*) the twins form penetration twins, taking the form of a cross. Outlines sharp	
Na_2SO_4 with $Al_2(SO_4)_3$ and $Cr_2(SO_4)_3$		See *Alums*						
$Na_2SO_4\,CaSO_4$		See *Alums*						
$Na_2SO_4\,MgSO_4 + 6H_2O$		See *Ca*						
		See *Mg*						

[1] I have followed Roscoe and Schorlemmer. Fock does not notice $NaHSO_4$, but gives $NaHSO_4 + H_2O$ as a Monoclinic [illegible]

			Sy.		Double Re. Shows Colours of.	Major Axis.	Properties.	Remarks.
Sodium.								
$Na_2SO_4 Mn SO_4 + 2H_2O$		See *Mn*						
$Na_2SO_4 Mn SO_4 + 4H_2O$		See *Mn*						
$Na Li SO_4$		See *Li*						
Ammonia.								
$(NH_4)_2 SO_4$	79	Mascagnite	R	Long flat prisms Laths with rectangular tops common	Some as high 6th order	*R.L.* to *e*		No. 79. Long rod-like liquid cavities containing air bubbles running with the length of the crystal are common. This salt is said to be isomorphous with K_2SO_4 but they may readily be distinguished under the microscope. There is a striking difference between them in their refraction; their double refraction is different, and the crystals of $(NH_4)_2 SO_4$ are much larger and flatter than those of K_2SO_4. No. 79 dissolves at 0° in 71 and at 100° in 97·5 parts of water.
$(NH_4) H SO_4$	80		R	Stumpy prisms; complex shapes, six-sided outlines not uncommon. Twinning common	Very high, probably near Calcite	*R.L.* to *e* when elongated. ‖ to twinning plane of one twin, sometimes of both		No. 80. Very deliquescent. Aqueous solution deposits crystals, but does not completely evaporate in the open air at the ordinary temperature.

	No.	Name.	System.	Form.	Double Refraction shows Colours of.	Direction of Major Axis.	Other Optical Properties.	Remarks.
AMMONIA.								
$(NH_4)_2SO_4$ with Al, Cr, &c.	—	See *Alums*						
$(NH_4)LiSO_4$	—	See *Li*						
$(NH_4)_2SO_4MnSO_4 + 6H_2O$	—	See *Mn*						
$(NH_4)_2SO_4MgSO_4 + 6H_2O$	—	See *Mg*						
RUBIDIUM.								
Rb_2SO_4	81		R	(*a*) 6-sided plates of hexagonal habit (*b*) Lath-shaped with ragged ends (*c*) Regular well formed crystals with complex shapes round edge of drop	4th order	(*b*) *R.L.* to *e* (*c*) Various	(*c*) Absorption with single nicol. Multiple twinning almost invariable	See Remarks No. 53.
$Rb_2SO_4Al_2(SO_4)_3 + 24H_2O$	—	See *Alums*	R					
$Rb_2SO_4MgSO_4 + 6H_2O$	—	See *Mg*						
$RbLiSO_4$	—	See *Li*						
STRONTIUM.								
$SrSO_4$	82	Celestine	R	Globulites, round and almond-shaped disks, and in prisms	White of 1st order	In almond-shaped disks ‖ to longer axis		No. 82. Solubility in water between $CaSO_4$ and $BaSO_4$; viz. 0·015 parts dissolve in 100 of water at 60° F. It is less soluble in boiling than in cold water. When $SrSO_4$ is dissolved in hot concentrated H_2SO_4 crystals of

	No.	Name.	System.	Form.	Double Refraction shows Colours of.	Direction of Major Axis.	Other Optical Properties.	Remarks.
STRONTIUM.								
$(Sr\ Ba)\ SO_4$	83	Baryto-Celestine	R					
TITANIUM.								
$Ti\ (SO_4)_2$	84	Normal Sulp.	—					
$(Ti\ O)\ SO_4$	85	Basic Sulp.	—	White hard mass				No. 85. Obtained by dissolving dry titanic acid in boiling H_2SO_4 and evaporating
$Ti_2\ (SO_4)_3 + 3H_2O$	86		—	A resinous transparent yellowish deliquescent mass				No. 86 is formed by the oxidation of the sesqui-sulphate with Nitric Acid and evaporating
$Ti_2\ (SO_4)_3 + 8H_2O$	87		—	Crystals in tufts				No. 87 is obtained by dissolving the metal in dilute H_2SO_4
ZIRCONIUM.								
$Zr\ (SO_4)_2 + 4H_2O$	88		R	Spherulites, elongated lozenges, and 6-sided micaceous looking thin plates. Spherulites often constricted in the middle like dumb-bells	3rd Order	‖ to *e* Spherulites ‖ to axis of *Q.W.*	Absorption with a single nicol. The elongated lozenges are deeply scored with numerous fine dark lines, which give them the appearance of bundles of micaceous plates	Swells up on heating with alum. Decomposes at a red heat

Part III.

Aluminium.[1]

Cæsium chloride is usually recommended as a test for the salts o aluminium, the reaction yielding cæsium-aluminium-alum (cubic), bu inasmuch as CsCl itself crystallises in the cubic system, there is seriou danger of the reagent being mistaken for the desired product. The sul phates of Cs or Rb are more suitable (Cs_2SO_4 is recommended), as the both crystallise in the rhombic system and cannot therefore be mistake for cæsium-alum. See alum *ante*.

It is essential that samples of the sulphates obtained from the minera under examination should be crystallised on glass slides prior to th addition of Cs_2SO_4, or Rb_2SO_4, in order to be sure that the mineral doe not yield an alum without the addition of the reagent. When Mg as wel as Al is present, as $MgSO_4$ forms monoclinic double salts with Cs_2SO_4 an Rb_2SO_4 (see Nos. 61 and 62, Part II.), sufficient of the reagent must b used to satisfy any $MgSO_4$ that may be present and leave sufficient over t convert the Al-sulphate into Cs- or Rb-alum. The advantage of Cs_2SO_4 or Rb_2SO_4, is that neither of these reagents forms alums with the sulphate of other metals (see alums).

Barium.

The sulphate of barium is almost insoluble in water (1 in 400,000), an barium precipitated by H_2SO_4 has no crystalline form under the micro scope. The sulphate, however, dissolves to a considerable extent in ho concentrated H_2SO_4 and deposits on cooling crystals, having the composi tion $H_2SO_4 + BaSO_4$ and $H_2SO_4 + BaSO_4 + 2H_2O$. Very frequently bot are deposited together, the character of the deposit depending a goo deal on the condition of the atmosphere at the time. If the air is dam the hydrous salt may predominate; if it is dry the anhydrous salt may b the one principally found on the glass slide. $H_2SO_4 + BaSO_4$ is i microscopic four-sided[2] transparent crystals (*a*) as shown in figs. 20, 21

[1] The bases in Part III. are arranged alphabetically with reference to thei *symbols*; soda, for instance, being under the letter *N*.

[2] By this and similar expressions it is intended that as seen in transmitte light, the crystal has a four-sided *outline*.

e of the four sides is very commonly a little longer than the others, d this side is frequently curved inwards like a concave lens. These all transparent crystals have straight extinction. More rarely crystals hexagonal and more complex outline are formed. When the hot acid exposed to a current of air, especially damp air, large skeleton crystals are formed which bear considerable resemblance to negative ice crys-s. These are the skeleton forms of tabular rhombic crystals, and every nsitional form up to a perfect rhomb may be seen. Some of these are picted at figs. 19, 22-25. The skeletons extinguish in a line bisecting arms, as indicated by the dotted lines and the letters N.S. in the stration (figs. 22 to 25). This is a very interesting fact, it seems to , which throws light on the process of crystal building. Each mole-e of these embryo crystals (figs. 22, 23) appears to be orientated not reference to its present, but with reference to the ultimate form of the ect crystals (fig. 25). Each molecule appears to have been endowed (what for want of a better term we must call) polarity, and to have ched itself to its neighbour in a way that needed no subsequent ification as the mineral grew from a crystallite into a perfect crystal.[1] fact that some embryo crystals of doubly refracting minerals show little or no double refraction is, I think, due to the fact that owing their excessive thinness they do not show colours between crossed ols.

The sulphuric acid test is a delicate and sure one. It may be com-ed with ordinary testing in the following way: Place some of the id to be tested in a test tube or watch glass. If H_2SO_4 gives a white , evaporate to dryness. Add concentrated H_2SO_4; heat for some e; draw off some of the clear, hot, H_2SO_4 with a pipette and place a drops on a warm slide. If anhydrous crystals (*a*) be desired allow H_2SO_4 solution to cool gradually in a warm dry room. If the hydrous (*b*) be desired, allow the H_2SO_4 to cool in or near an open window or osed to steamy air. If the preparation is to be mounted in Canada am allow the slide to stand for 24 hours, then cautiously drain off the H_2SO_4 with strips of filter paper.

2.) If barium is present as sulphate I convert it into the chloride by following process:—Evaporate solution to dryness; mix powder in e mortar with sufficient charcoal to make the mixture dark grey in ur. Heat in small covered earthenware crucible strongly for one over a Bunsen burner. This converts the sulphate into the sul-

[1] For another illustration of the same principle see Calcium (2).

phide. Dissolve in dilute HCl and heat until all the sulphuretted hydroge is given off; filter, evaporate to dryness; dissolve in water and allow few drops to evaporate on a glass slide. The crystals of $BaCl_2+2H_2$ (*Monoc.*) thus obtained are in square prisms very much resembling thos of augite in shape. They almost always exhibit a very characteristi polysynthetic twinning closely resembling the albite-baveno and albit pericline twins of felspar. Two sets of these twins may sometimes b seen. Each set of multiple twins is apparently parallel to a pinacoid face and they intersect at about 90°. A third and fourth set may also b seen, which appear to be parallel to the prismatic faces.

(3.) With a solution of tartar-emetic barium chloride yields tabula rhombs with two acute angles of about 50° each. Sometimes one or bot of the acute angles are cut off, giving six-sided forms. They extinguis parallel to a line bisecting the acute angles, and the major axis is parall to that line. They polarise brilliantly in colours of the 1st and 2nd orde These crystals very commonly exhibit multiple twinning, the twinning plan being parallel to a line bisecting the obtuse angles of the rhomb.

Beryllium (*Glucinum*).

The principal reaction mentioned in Klement and Renard's *Réactio Micro-chimiques* is the bichloride of platinum, but I do not think this to be relied on when the beryllium to be tested is in the form of sulphat for this salt and the chloroplatinate of beryllium both yield crysta belonging to the tetragonal system and consequently one might be mi taken for the other.

(1.) The monoclinic salt may be obtained by dissolving the normal sa (tetragonal) in H_2SO_4. See Part II.

(2.) The double salt with K_2SO_4 is very characteristic. See Part II.

(3.) On the addition of KOH solution a p.p. of white flocculent Be(OH forms which dissolves in an excess of the precipitant or on application heat. A p.p. reforms on addition of a few drops of ammonium chlorid The p.p. formed by KOH, on being allowed to crystallise spontaneousl deposits crystals of K_2SO_4 imbedded in $Be(OH)_2$. The latter appears i radiating sheaves, apparently monoclinic. Extinction $0°-25°$ to *e*, an this is also the major axis. Double refraction very high, reminding o of calcite.

(4.) By treating a solution of the sulphate with a solution of ammoniu carbonate very remarkable crystals of beryllium carbonate may be obtaine which I think have not yet been described. If too much of the a

onium carbonate is used the mixture will yield a white opaque amorphous ass; if too little is used the result will be a structureless glass; but if the ght proportion of the reagent is added a carbonate is obtained that gives ystals which resemble bivalve shells in a remarkable manner (see figs. 7, 8 d 9). This resemblance is increased by the fact that they project, some- nes standing up on edge, sometimes lying more on their sides, from a ound-mass of granular ill-formed crystals that look extremely like a atrix of broken shells. The large and perfect crystals have two discoidal ces (resembling the upper and lower valves of shells) joined by a sharp ge, which is very frequently truncated at one side in a way to simulate e hinge of a bivalve shell. (See fig. 8.) Straight extinction: viz. || to is of elongation. Major axis || to *e*. Between crossed nicols these ystals polarise in the blue of the 2nd order. Twinning is not un- mmon. The combinations presented are varied, but that depicted at fig. is a common type. After mounting in Canada balsam the crystals adually become more or less corroded.

(5.) The reagent recommended by Behrens is potassium oxalate, t the objection to this is that the results vary greatly with the proportion the reagent to the beryllium salt. I obtained with one drop of the gent a mass of globulites showing a cross under crossed nicols, and l. from 2 to 6 drops: (*a*) massive crystals; (*b*) dendritic arrangements stling with very sharply pointed spear heads (rhombs with one of the te angles projecting); (*c*) lenticular crystals (with rather sharp minations) shaped like a Zulu shield; and (*d*) rosette-like groups of composed of two or more individuals. Extinction in (*b*) oblique; in and (*d*) straight, viz. || to *e*. Double refraction: (*b*), (*c*), and (*d*) larise brilliantly in the blues and reds of the 2nd order. Refraction ong. I have not observed any twinning in (*c*) or (*d*); the groups of ystals (*d*) are not in my specimens penetration twins, but thin plates over- pping each other.

Calcium.

Gypsum ($CaSO_4 + 2H_2O$), the form in which the sulphate crystallises m aqueous solution under ordinary conditions, is soluble in the propor- n of one part in 500 parts of water at the ordinary temperature. The ximum solubility is attained at about 35°, after which it declines. I find practice that by boiling powdered gypsum in water for from 10 to 15 nutes sufficient of the sulphate is taken up to give good typical crystals en a few drops of the solution are allowed to evaporate on a glass

slide. The crystals usually lie on the 010 face, and are commonly elongated in one direction (apparently 110). Gypsum prisms are often very slender and radiate from a common centre like the rays of a star. This grouping of slender needle-shaped prisms is very characteristic of the mineral, but it must not be accepted as conclusive evidence of its identity, as several other salts have a similar habit, and some of these have an oblique extinction similar to gypsum.

More important, to my mind, is the presence of very peculiar twins, which have always been present when I have allowed an aqueous solution to evaporate spontaneously on a glass slide. See figs. 26 to 31. The re-entering angles appear to be formed by the prism faces (110), as a fibrous striping (110 cleavage) is very distinct on almost every twin crystal. Sometimes this has a curious resemblance to polysynthetic twinning. The twin crystals depicted at figs. 26 to 31 disappear when they are mounted in Canada balsam. Owing to their thinness and the consequent feebleness of their double refraction, they rarely show even between crossed nicols.

At figs. 27, 31 a curious notching of the faces may be observed. When this is deep, and the crystals are wider in proportion to their length than those shown in the illustration, the twins assume the appearance of a star or rosette. The sides are usually curved, as shown in figs. 26, 27, and 29.

Another very common and characteristic form is that of a prism shaped like fig. 36. These prisms are usually isolated from other crystals, but sometimes they appear in combination with other forms, as, for instance, in (*e*) (*d*) of figs. 26, 29-31. The major axis of elasticity, *ma* of fig. 36, is theoretically 37°28′ from the axis of elongation, measured towards the acute angle of the rhomb, but it varies, I find, from 33° to 43°.

The above characteristic forms are often seen together on the same glass slide.

(2.) If a few drops of calcium sulphate in aqueous solution are placed on a glass slide and a couple of drops of ammonium carbonate are added, the solution becomes clouded. On spontaneous evaporation numerous grains and congeries of grains of calcite are left on the glass. Long filamentous crystals, or strings of grains, are not uncommon, and these occasionally form skeleton rhombs, the obtuse angle of which varies from 105° to 108°. The high refraction and double refraction of calcite makes the detection of calcite crystals very easy. Being thin they usually polarise in brilliant colours. I have not succeeded in making magnesium carbonate in the above way, otherwise the latter might be mistaken for $CaCO_3$.

(3.) Concentrated H_2SO_4 raised to the boiling point dissolves $CaSO_4$ to a rtain extent, and deposits, on cooling, a salt which, according to Roscoe d Schorlemmer,[1] consists "of microscopic prisms which have the com- sition $CaSO_4 + H_2SO_4$." The results obtained by me are as follows: ittle of the hot acid solution allowed to cool slowly on a glass slide, and to nd for some time, deposits embryonic crystals consisting of round and al disks and moss-like clumps, the latter of which, under high powers, are n to be composed of spicules sticking out in all directions. More rarely croscopic crosses consisting of four arms and obscurely shaped crystals y be seen. Straight extinction, viz. parallel to the longer axis of the oval ks and to the arms of the cross. Major axis at right angles to the ger axis of the oval disks; relief good; the disks polarise in the yellow the first order. The round disks in transmitted light are rather gestive of silkworms' eggs; in reflected light they are a dull dead white. Sometimes I have obtained a quantity of well-shaped crystals of the m shown at fig. 5; the sharp bows of these boat-shaped prisms meet at angle of about 62°. At other times I have obtained crystals of the pes shown at figs. 1-4. That at fig. 1 is not a thin platy crystal, but ng to the action of free H_2SO_4 on the balsam, and other causes, it is difficult to make out the precise shapes of the side faces. Sometimes op seems to be four-sided (like fig. 2), and the side faces to be six- ed like the outline of fig. 5; but they cannot be made out exactly. these crystals (figs. 1-5) appear to belong to the orthorhombic system, l the mineral I doubt not is anhydrite ($CaSO_4$).

Cerium.

Klement and Renard put in the foreground as tests oxalic acid and monium oxalate, but I have not obtained any very reliable results from se. I prefer ammonia as a test. This does not yield crystals, but its ults are striking. If a drop of $CeSO_4$ solution is placed on a glass de and a drop of liquid ammonia is placed near it, the vapour from the ter, even when the drops are not allowed to touch each other, causes $CeSO_4$ drop to assume a beautiful opalescent appearance. If the drops allowed to evaporate side by side, or if ammonia be added to the $CeSO_4$, isotropic deposit is formed which shrinks considerably as evaporation ceeds and becomes scored with cracks that give it the appearance of a

[1] Vol. II. (1), p. 203.

slice of serpentine. When unmounted the dried deposit generally exhibits like opal, a blue and red sheen.

(2.) With ammonium formate crystals of cerium formate, $Ce_2(Co_2H)_6$, are deposited in rounded, or six-sided, generally opaque white clumps, made up of micro-prisms which usually project from the edge of the mass. They have straight extinction. Direction of major axis doubtful. On mounting in balsam a few become translucent and show colours up to the blue of the second order. They look like radiating bunches of feathers, each feather with a central shaft and side barbs.

(3.) With K_2SO_4 (see remarks Part II.) cerous sulphate forms double salts. Under the microscope these form transparent hexagonal disks, microscopic crystals of complicated structure, some of which have pyramidal terminations, globulites, and irregular hexagonal disks made up of overlapping or irregularly grouped crystals. The apparently heterogeneous internal structure is increased by numerous inclusions of opaque matter. When the globulites are densely packed together so as to form an opaque crust, they often appear in reflected light like branching stalks of coral. Refraction high; double refraction never higher than blue of 2nd order.

(4.) With Na_2SO_4 and $Ce_2(SO_4)_3$ in the right proportion we obtain small four-sided prisms terminated by sharp pyramids at both ends, or lenticular granules with sharp ends often arranged in groups like flowers with four petals. Extinction $\parallel$ to *e*. Major axis at right angles to *e*.

(5.) With potassium ferrocyanide, cerous sulphate yields (*a*) hexagonal disks; (*b*) short hexagonal prisms lying on their sides; and (*c*) stars with six rays, each star being an embryo hexagonal disk. The passage of the star into the hexagonal disk may often be seen, the almost complete form being a hexagonal disk with a dark line running from the centre of each face towards the centre of the crystal. Other forms also occur, viz. (*d*) four-rayed stars passing into: (*e*) short prisms of cube like aspect; (*f*) bundles of bud-shaped crystals; (*g*) rounded complexes of small crystals suggestive of marigold flowers; and some variations of the skeletal form. (*d*). (*a*) and (*c*) remain dark between crossed nicols; (*b*) and (*e*) have straight extinction; (*d*) polarises parallel to a line bisecting the rays of the star, and (*f*) to the axis of bundle. Major axis $\parallel$ to length of prism in (*b*) and at right angles to longer axis of (*f*).

Cobalt.

(1.) If potassium nitrite solution be added to the aqueous solution of $CoSO_4$ and then acetic acid to strong acid reaction, and the mixture gently

rmed, a beautiful yellow precipitate (resembling the colour of chrome llow) is formed. Under the microscope this yellow deposit ($K_6Co_2N_{12} + H_2O$) is seen to be made up of very small isotropic crystals in the shape four-rayed stars or crosses with short arms. These are said to be the eletons of crystals belonging to the cubic system. They require a $\frac{1}{6}$ h objective and 2nd eye-piece for their definition.

(2.) Solutions of cobalt that do not contain nickel, as an impurity, are d in Klement and Renard's work to give with oxalic acid the oxalate of balt ($CoC_2O_4 + 2H_2O$) in rectangular flat prisms (straight extinction) ich are often grouped as rosettes, and one is referred to Plate VI., fig. 11, their work for the form of these rosettes. Oxalic acid (straight extinction) elf, however, sometimes occurs in radiating groups of fine prisms exactly those represented, and it seems possible that, in this case, the reagent y have been mistaken for the oxalate of cobalt. In my experiments e reaction has yielded white opaque globules with rough edges suggestive a resemblance to the spores of ferns. Among these there are also merous slender crystals of oxalic acid, some of which are in radiating r-shaped groups.

Chromium.

(1.) For the following test the chromium salt should be converted into alkaline chromate by ignition with potassium nitrate and an alkaline rbonate. Dissolve the resulting chromate in water and then neutralise e alkaline solution with acetic acid. Add a drop or two of a solution nitrate of silver. The liquid turns blood red. On spontaneous aporation microscopic crystals of chromate of silver are deposited g_2CrO_4). Sometimes these crystals are in very minute and short rods, d remind one of a clotted mass of some species of microbe, at other nes they are of larger size and more irregular shape. They are then en to be of blood red colour in transmitted light, and to be transparent translucent. In any case they require a $\frac{1}{5}$ inch objective and the 2nd e-piece. As the chromate of silver is insoluble in water all trace of the romate of potash can be removed by washing. The residue dissolves adily on the addition of a few drops of ammonia to the slide, and on aporation thin, branching, moss- or lichen-like clumps and tufts of $g_2CrO_4 + 4NH_3$ are deposited. These tufts are opaque to translucent, e latter being of blood red colour in transmitted light. Powerful absorp- n with a single nicol (blood red to nearly black), but between crossed cols the double refraction is so feeble as to be nearly nil. In reflected

light the crystals have a brilliant metallic lustre. These crystals are sai (Haushofer, quoted by Klement and Renard, p. 44) to occur in elongate rhombic plates, but I have not obtained any that exhibit a definite crystallo graphic form.

(2.) To the dichromate add a drop or two of barium chloride. O evaporation the chromate of barium ($BaCrO_4$) will be found on the slide This is insoluble in water, and is of yellowish white colour and of granula texture. If the solution was strong the deposit will be opaque and dotte over with the cubic crystals of potassium chloride. If very dilute th barium chromate commonly yields skeleton crystals in the form of four armed crosses. The arms of these crosses are varied and irregular i shape, but they all more or less resemble the fronds of a fern wit transverse lobes. They require $\frac{1}{5}$ inch objective and have only a feebl action on polarised light. See fig. 6.

Cæsium (Cs).

Stannic chloride[1] gives with Cs_2SO_4 (orthorhombic system) a multitud of micro-crystals belonging to the cubic system (principally octahedrons and star-shaped skeleton crystals, shaped like negative ice crystals, bu consisting usually of three (occasionally four) rays.

Cæsium chloride gives with the above reagent small octahedrons an colourless crystals of the cubic system shaped like fig. 11. The latte usually predominate. Cæsium chloride itself crystallises in the cubi system (Cs_2SO_4 is therefore to be preferred), but its habit is different fro Cs_2SnCl_6. I have always found cæsium chloride crystallise in cubes lik common salt.

The bichloride of platinum gives with the salts of NH_3, K, Cs, and R crystals similar in shape to those of Cs_2SnCl_6.

Iron (Fe).

The ferro- and ferri-cyanides of potassium give such delicate an characteristic reactions that hardly any other tests are required to detec the presence of iron. Basic sulphates, about which little seems to b known from a microscopic point of view, are numerous, and they form o the application of heat or on a solution being allowed to oxidise in the air and this renders the determination of iron with the aid of the microscop very difficult. Of microscopic tests the following may be mentioned:—

[1] $SnCl_4 + 3H_2O$ (in needles); $SnCl_4 + 5H_2O$ (opaque acute prisms); $SnCl_4 + 8H_2$ large transparent crystals. These hydrates all crystallise in the monoclinic system

11.) With oxalic acid ferrous sulphate gives greenish yellow crystals of rous oxalate ($FeC_2O_4 + 2H_2O$, solution 1 in 3,800). They are of roscopic size, belong to the orthorhombic system, and have their or axis of elasticity at right angles to *e*. They are ordinarily rect-gular in shape but are sometimes prisms with six sides terminated by nes. They polarise rather brilliantly.

12.) With ferrous sulphate, ammonia throws down a whitish p.p. which irst turns green and ultimately a dull red colour. When dried on the ss slide it closely resembles a drop of dull red sealing wax on which a n seal has been impressed. It is only translucent here and there, ng in transmitted light of bright orange-red colour. With ferric bhate ammonia throws down at once a foxy red p.p., which forms on poration an amorphous translucent glass of much brighter red than t formed by $FeSO_4$.

13.) When ferric sulphate is dissolved in boiling water several salts m to be formed. When allowed to evaporate on glass slides my speci-ns contained : (*a*) needle-like prisms in groups radiating from an opaque morphous centre ; these seem to be No. 34, Part II. ; (*b*) hexagonal y plates of micaceous habit ; these seem to agree with No. 39, Part and (*c*) spherulite rounded disks composed of radiating platy crystals mbling two open fans arranged so as to form a circle. They polarise liantly and show radiating stripes of colour. Major axis || to axis of rtz wedge. It is difficult to say whether these disks are No. 34 or 39 of Part II., or some other basic salt.

14.) The ferrous sodium double salt (Part II., No. 41) on first crystal-g forms an isotropic structureless glass. After standing for some e time it parts with some of its water and passes into the crystalline dition, forming masses of long prisms radiating from different centres, ch polarise brilliantly. After further exposure to the air, and further of water, the salt gradually becomes a white opaque mass. This cess, which is attended with loss of weight, takes place in a somewhat ricious manner, drops from the same solution evaporated side by side aving differently. Some take a short cut to the white opaque stage nce ; others take as much as from 6 to 10 days to accomplish it. process may be stopped by mounting in Canada balsam.

15.) The ferrous and the ferric sulphates treated with ammonium ride yield numerous small octahedra, cubes and other forms of the c system, the octahedra being by far the most numerous. Interesting s of penetration twinning frequently occur.

Potassium (K).

A very delicate test is the reaction with the bichloride of platinum ($PtCl_4$). It is absolutely indispensable that this reagent should be pure and that its purity should be tested by evaporation on a glass slide and microscopic examination before it is used. The bichloride commonly sold contains potash and yields crystals of chloroplatinate of potash described below. The pure bichloride (that is to say the purest I have been able to obtain) crystallises in long slender prisms like blades of grass. Extinction takes place nearly parallel to the length of the blade. Major axis parallel to *e*. The blades polarise brilliantly, usually in the blue and pink of 2nd order. The reagent must not be kept in glass bottles. I use a gutta-percha one. If a drop or two of this reagent be added to a few drops of the sulphate of potassium (or to a neutral or feebly acid solution of any other K-salt) yellow crystals of chloroplatinate of potash (K_2PtCl_6, solution 1 in 100) are formed. These are either octahedrons or combinations of the octahedron and dodecahedron, or some other form of the cubic system. The complex forms, however, almost always exhibit a six-sided face (a triangle with the corners cut off) of deep orange yellow colour, the other faces of the crystal at various angles to the plane of the glass slide, owing to the high refraction of the mineral remain dark in transmitted light. See fig. 11. Sometimes skeleton crystals in trefoil form, or with four arms arranged as a cross, are formed.

An excess of free H_2SO_4 is unfavourable to this reaction.

The salts of ammonium, cæsium and rubidium give with the bichloride of platinum crystals belonging to the cubic system similar in shape to those of K_2PtCl_6.

Lithium.

(1.) Phosphate of soda produces a precipitate of phosphate of lithium $Li_3PO_4 + H_2O$, (solution 1 in 2500) which forms in dagger-shaped crystals (two short transverse arms representing the hilt), or in star-shaped crystals composed of four or five rays. These crystals are interspersed among numerous globulites, which give a dark cross between crossed nicols. Most of these globulites are divided into approximately two halves (see *e* fig. 32); and when resolved between crossed nicols, in parallel light, the cross opens up into two hyperbolic branches like axial sections of some biaxial crystals in converging polarised light (see fig. 34). The curvature is greatest when the axis of the hyperbola is at right angles to the dividing

e (fig. 34). In elongated individuals the result between crossed nicols
an elongated cross with two transverse arms, one on either side of the
ding line. See fig. 35. These elongated twins are very suggestive of
multiplication of organic cells by fission. Indeed the resemblance is so
se that one may readily obtain on the same slide illustrations of this
posed fission at every stage. The optical phenomena noted above are
y curious, but, pending the completion of some investigations which I
carrying on, I think it better to postpone any attempt to explain them.
The crystals of lithium phosphate possess strong refraction, which
ws itself in the dark boundaries of the globulites, and in the strongly
nkled surface of the crystals. The latter have straight extinction.
e addition of acetic acid increases the number of globulites.

1.) With the reagents mentioned below (see Magnesium, No. 2)
tals isomorphous with those of struvite are obtained. They also
bit similar optical properties. A little warmth assists the reaction
the phosphate of soda should be added in crystalline form. Manganese
s also yield similar results with these reagents.

Magnesium.

1.) With ammonia the sulphate yields a gelatinous precipitate which
spontaneous evaporation forms a colourless mass with a silky gloss on
This is the monoclinic double salt $MgSO_4 (NH_4)_2 SO_4 + 6H_2O$ (see
t II.). Prepared on a glass slide this salt usually appears in crystals
auged like the shaft and web of a bird's feather. Mounting in Canada
sam appears to decompose the double salt. In every instance in which
ave tried the experiment the monoclinic crystals of the double salt
e broken up into needle-shaped orthorhombic prisms, presenting the
earance and optical properties of $MgSO_4 + 7H_2O$.

2.) Add a *little* ammonium chloride (cubic) to a dilute solution of
SO_4 (orthorhombic) in water. Place a few drops of this mixture
a glass slide. Place a drop of an aqueous solution of sodium phos-
ate (monoclinic) on the slide near it, and to the latter add one or
drops of ammonia. Then join the two drops. On evaporation
uvite crystals will be found on the glass slide. As hemimorphism is
mmon the shapes of the crystals are varied, but those shown at figs. 12
15 are often seen. That depicted at fig. 12, usually spoken of as the
fin-shaped form, is especially characteristic. The struvite crystals,
$(NH_4) PO_4 + 6H_2O$ (solution 1 in 15,000), belong to the orthorhombic
tem. They polarise brilliantly in the colours of the 1st and 2nd order.
jor axis *RL* to *e*.

Most writers recommend the gentle warming of the drops prior to mixing, but I have not found it necessary. Behrens adds the phosphate of soda solid. This may be useful in some cases. The reaction requires a little practice.

Crystals similar in shape and optical properties are also produced by the action of the above reagents on the sulphates of lithium and manganese.

(3.) On adding some drops of the aqueous solution of potassium antimonate to the aqueous solution of $MgSO_4$ (the proportion of the latter to the antimonate should not be too great) numerous microscopic crystals of the acid pyro-antimonate of magnesia ($MgH_2Sb_2O_7 + 9H_2O$) are formed on the slide. These occur, for the most part, in six-sided disks lying on their basal planes, but also, not unfrequently, on one of the sides of the hexagonal prism. They also occur in cube-like prisms (sometimes slightly elongated in one direction), and in the form of little flowers, like primroses, with four (occasionally five) uniform petals. The hexagonal disks sometimes pass into globulites, and the latter are doubtless the immature form of the former. Penetration twins are not uncommon and their forms are very varied. Double refraction is not strong and sometimes it is nil. Fock refers the crystals of pyro-antimonate of magnesia to the hexagonal system.

Manganese.

The blowpipe and ordinary chemical tests are the most reliable for the detection of manganese.

(1.) Manganous sulphate (or other manganous neutral or feebly acid salt) treated with oxalic acid yields crystals of oxalate of manganese ($MnC_2O_4 + 3H_2O$) in radiating groups of elongated prisms with straight extinction; but as oxalic acid itself forms similar prisms, and groups of prisms with straight extinction,[1] this reaction is not recommended.

(2.) Ammonia produces a white p.p., which on exposure to the air becomes of dark brown colour (chloride of ammonium prevents this precipitation). On allowing this to evaporate spontaneously on a glass slide, the crust formed is partly transparent and partly opaque. Under the microscope in transmitted light the crust becomes a very beautiful object, and is seen to be made up of fern-like fronds arranged in group

[1] Oxalic acid is said to crystallise in the monoclinic system, but the prisms obtained on a glass slide have straight extinction. Double refraction very high. Major axis $\parallel$ to *e*.

a rich yellow-brown background. The transparent portions (sometimes fronds are transparent—sometimes opaque) extinguish in a direction que to the stems of the fern-like forms.

3.) With phosphate of soda $MnSO_4$ gives the same results as Li_2SO and SO_4. For details see Mg, Part III. No. 2.

Sodium (*Na*).

The blowpipe and flame reactions are principally to be relied on for detection of soda. Szabo's well known method is a most useful one. following is the process for microscopic testing which I follow. s good but a somewhat troublesome method.

.) Reduce the mineral to a fine powder in an agate mortar; ignite latinum crucible; regrind in mortar; ignite; add hydrofluoric acid stir; heat gently for some time in platinum dish or crucible (agitating liquid from time to time and adding more HF aq. if necessary) until powder, or as much of it as is soluble in HF aq., is dissolved. add water, and then heat again. This operation converts the soda silica present into sodium fluo-silicate (Na_2SiF_6). Should the mineral ated on not contain silica, pure silica must be added. A glass slide t now be prepared by giving the central portion of it a thin coating of tened Canada balsam. A few drops of the liquid are then removed by ns of a platinum spoon (all the platinum employed must be pure from surface trace of soda) and transferred to the prepared glass slide. If liquid does not completely evaporate in 48 hours the surplus can be oved by bringing a strip of filter paper into contact with the outer e of the drop. When this has been done the crystals left on the slide be mounted in the usual way.

he most characteristic crystals of sodium fluo-silicate are six-sided ms; sometimes short and terminated with rather flat pyramids (in h case they much resemble micro-crystals of quartz); sometimes paratively long and terminated at both ends by flat basal planes. tration twins are not uncommon, and other forms also occur. Before nting the crystals sometimes lie with the apex of the flat terminal mid turned towards the eye of the observer. In the process of nting they get turned over on their sides. Straight extinction. Major parallel to length of prism. Double refraction—white of the 1st r.

rystals of fluo-silicate of soda are isomorphous with those of the fluo- ate of soda.

Rubidium.

(1.) The reaction of the salts of rubidium with platinum bichloride the same as that of the salts of potassium, cæsium and ammonium. Se potassium.

(2.) For reaction with fluoride of titanium see titanium, No. 2 Part III.

Silica.

The reaction for silica is the same as that for sodium (see *ante*). If th mineral to be tested does not contain soda, some soda must be added Crystals of fluo-silicate of soda are isomorphous with those of fluo-titanat of soda.

Strontium.

Strontium sulphate dissolves in hot concentrated H_2SO_4 like $BaSO_4$ (se *ante*). On cooling embryo crystals are deposited, the lowest form o which is the micro-globulite. More advanced forms present themselve in the shape of disks, oval crystals, and acicular prisms (often forked which sometimes arrange themselves in rosettes. The prisms and almond shaped bodies occasionally develop radiating tufts at one or both ends The most developed is the arrangement of almond shaped bodies in th form of a short cross with oval arms (see fig. 16) which gradually grow by the filling up of the re-entering angles, into a four-sided tabula crystal. Not unfrequently we get either a combination of lenticula crystals, or two disks at right angles to each other, as shown at fig. 17 The suppression of one half of one of the disks produces a hat-like form (fig. 18) which is not uncommon. In all these crystals the unit is clearl a globulite. Even the most advanced forms (the four-sided tabula crystals) may sometimes be distinctly seen to be built up of globulites.

The double refraction is feeble, showing only the grey white of the 1s order. Major axis parallel to *e* in oval disks. Straight extinction, vi parallel to *e* in oval disks. In the cross-like forms extinction is paral and at *R.L.* to each arm. The more gradual the cooling the more th cross-like forms abound. After mounting in balsam I have obtained com paratively large crystals of celestine (orthorhombic).

Klement and Renard state on the authority of Haushofer that a mixtu of equal parts of the sulphates of Sr and Ba dissolved in hot concentrate H_2SO_4 gives on cooling crystals in the form of $SrSO_4$ only; Behrens sa

same. My experiments do not confirm this. I have under the above cumstances obtained typical crystals of $BaSO_4$.

Titanium.

1.) Titanium dioxide dissolved in hydrofluoric acid[1] gives with the ts of potassium monoclinic crystals of fluotitanate of potassium $K_2TiFl_6 + H_2O$) in rectangular crystals, rhombs, and elongated six-sided sms. The truncation of the corners of the former give six- and eight-ed outlines. Polarisation feeble. The best results are obtained by placing rystal of the K-salt in contact with the acid solution. Crystals of oride of potassium cannot be mistaken for those of the fluotitanate, as extinction of the former is straight and the latter decidedly oblique.

2.) Strong solutions of rubidium chloride (cubic) and cæsium chloride bic) both give similar reactions.

3.) The fluotitanate of sodium Na_2TiF_6 (obtained by melting the sub-nce to be analysed in a bead of sodium fluoride, treating with cold er first, and afterwards with hydrofluoric acid, and crystallising on a ss slide) is isomorphous with sodium fluosilicate (see sodium *ante*). s reaction, therefore, is of no use when silica is present.

Zirconium.

11.) Two or three drops of an aqueous solution of potassium binoxalate ed to a solution of zirconium sulphate on a glass slide yield, on poration, crystals probably tetragonal (Behrens); they are in: (*a*) tangular and six-sided prisms, principally the former, lying apparently their basal plane with the apex of a pyramid turned towards the eye of observer; (*b*) crystals showing a six-sided face parallel to the plane he glass slide and bounded by faces that remain black in transmitted ht. These crystals present a *general* resemblance to those depicted at 11, but the arrangement of the side faces is not quite the same. (*a*) main dark between crossed nicols. (*b*) The central portion polarises l exhibits a limpid gentian blue of very beautiful tone; at the margin he drop, where the crystals are massive, the blue passes through et into red. None of the above crystals will bear mounting in Canada sam.

12.) Zircon (and other varieties of the silicate of zirconium) is decom-

[1] When HF aq., or a fluoride, is evaporated on a glass slide the glass must be tected by a thin coat of hardened Canada balsam, as otherwise Ca, K, and other es, would be extracted from the glass.

posed by fusion[1] with about five times its weight of pure anhydrou sodium carbonate. A little hydrous sodium carbonate (pure) should b added when fusion is nearly complete. After fusion treat the mass wit cold water for the removal of soluble silica; dissolve the insolubl residue with hydrochloric acid; evaporate to dryness; dissolve in wate acidulated with hydrochloric acid; the solution contains nearly pur zirconium chloride. Oxalic acid throws down zirconium oxalate. Th crystals I have obtained in this way appear, like those described under No 1, to belong to the tetragonal system. They present rectangular outline with pyramids pointing to the eye of the observer truncated by a plane the outline of which is a rhomb, the diagonals of which bisect the faces o the rectangle. Two of the edges of the pyramids are sometimes truncate towards their apex by planes which are apparently the pyramid of the 2nd order, and these planes also truncate the acute angles of th rhomb producing a six-sided outline. The rhomb alluded to polarises i the whitish yellow of the 1st order. Major axis parallel to a line bisect ing the acute angles of the terminal rhomb. Extinction parallel to th sides of the rectangle.

List of Illustrations.

Figs.	1— 5	Calcium sulphate (anhydrite).
,,	6	Barium chromate.
,,	7—10	Beryllium carbonate.
,,	11	Potassium chloroplatinate.
,,	12—15	Magnesium ammonium phosphate (struvite).
,,	16—18	Strontium sulphate dissolved in hot H_2SO_4.
,,	19—25	Barium sulphate dissolved in hot H_2SO_4.
,,	26—31	Calcium sulphate (gypsum) twins.
,,	32—35	Lithium phosphate in the form of globulites.

[1] Behrens recommends fusion with sodium fluoride and evaporating down wit sulphuric acid.

dditional Note on the Lamellar Structure of Quartz-Crystals, and the methods by which it is developed.

By Professor John W. Judd, F.R.S., V.P.G.S.

[Read April 12th, 1892.]

I a former communication to this Society,[1] I have demonstrated that quartz must now be added to the long list of minerals in which a ellar structure can be set up by mechanical stresses. In that paper, ystal of smoky quartz was described in which well marked lamellæ ld be detected; the relations of these lamellæ to the parts of the tal which had suffered mechanical deformation and crushing are such o leave no possibility of doubt that the lamellar structure is not an inal but a secondary one; while it is equally clear that the structure been developed by the action of mechanical forces upon the tal.

he manner in which these lamellæ in quartz terminate abruptly at dental cracks or die out gradually, precisely resembles in fact what be observed in the case of the twin-lamellæ of calcite, leucite, felspar, many other minerals: and in all of these cases we can prove, by eral different methods, that the structures in question have been loped subsequently to the formation of the crystals.

he position and relations of the lamellæ in the quartz-crystals in ques- were demonstrated by two different methods:—that of Des Cloizeaux, h consists in examining thick plates (cut equatorially from the crystal) olarised light: and that of Leydolt, which is based on the study of faces cut surfaces of the crystals that have been etched with hydrofluoric . In the case of some of the wider lamellæ, it was proved, by the use onvergent polarised light, that the alternate bands exercise opposite tory effects on the plane of polarisation, and that by the overlapping he right- and left-handed quartz, Airy's spirals are formed. The ding-planes" of quartz were shown to be parallel to R (100) and -2 ($\bar{1}22$).

[1] *Mineralogical Magazine*, Vol. VIII. (1888), pp. 1-8.

Although, as stated in my paper in 1888, an attempt was made to force quartz-crystals to yield along their gliding planes, firstly by alternately heating and cooling them, and secondly by crushing them in vices, ye neither of these methods afforded any very definite results. Quite recently however, my attention has been called by Mr. F. H. Butler to some results accidentally obtained by him, which, because of their bearing upon this interesting question, I think are worthy of being described and discussed before this Society.

Mr. Butler, to whom I must acknowledge myself as indebted for much valuable assistance and information in connection with this investigation has designed and employed a very powerful machine for breaking minerals and rocks in definite directions. It consists of two sharp steel-jaws which are capable of being moved in the same horizontal plane by means of a screw; a pressure amounting to many tons can thus be applied to a specimen, and under the powerful stresses set up in its midst the mass is eventually torn asunder.

In order to explain the phenomena detected by Mr. Butler in some of the quartz-crystals which he had crushed in his machine, I must call attention to the striking peculiarity in fracture, noticed long ago by Brewster, in quartz-crystals possessing a lamellar structure. As far back as 1819, Brewster pointed out that "the fracture across the veined portions" (of quartz-crystals) "exhibits a beautiful and sometimes a regular rippled structure, not unlike the engine-turning on the back of ornamental watches. This rippled structure is an infallible proof that the specimen is amethyst, whether it is *yellow*, *orange*, *olive-green*, *lilac*, or perfectly *colourless*."[1] Brewster, in short, proposed to separate the quartzes with lamellar structure from those without any such structure, and to call the former "amethyst"; and he suggested that in the "rippled fracture" we have a ready means of distinguishing "amethysts," whatever their colour, from common quartz. This proposal to separate amethyst from quartz as a distinct mineral species has not, it is scarcely necessary to say, been accepted by most mineralogists.

When the "rippled" fracture-surface of a laminated quartz ("amethyst" is carefully studied, the cause of the peculiarities which it exhibits becomes perfectly obvious. The different lamellæ yield in different ways to the force employed in producing the fracture, and the ordinary lines of the conchoidal fracture, which are often barely visible in the alternating lamellæ themselves, become frequently very strongly pro

[1] *Trans. Roy. Soc. Edinb.* Vol. IX. p. 149.

nounced along the lines where the lamellæ meet. This appearance can e equally well seen in incipient fractures, and in those in which actual paration of the parts has taken place, and in it we find a striking proof t the want of homogeneity in the crystal. The fracture, in fact, affords just the same kind of evidence concerning the differences in molecular ucture in the alternating lamellæ, as is supplied by the etching of faces cut surfaces of the crystal, with hydrofluoric acid.

The first specimen which I received from Mr. Butler exhibiting noteorthy peculiarities of fracture, was a quartz-crystal from Brazil about millimetres in diameter, and very free from included cavities or reign minerals. I satisfied myself by repeated trials that, when actured by a blow from a hammer, this quartz-crystal shows no tendency exhibit the peculiar rippled surfaces, and it has therefore no claim to regarded as a "white amethyst." But I found that when crushed in powerful vice and broken across a plane which traversed the crystal a nearly equatorial direction, the surfaces of fracture exhibit the engine-turned" appearance in a much more pronounced manner than y natural "amethyst" which I had ever seen. Mr. Butler has since wn me other Brazilian quartzes exhibiting the same peculiarities in a ry striking manner.

A second series of very interesting specimens was obtained by Mr. tler during the breaking up of a great mass of quartz, consisting of erpenetrant crystals, which, it is believed, came from Madagascar. e quartz in question presents many very interesting features. It is markably full of cavities of various sizes, which all contain a liquid with veable bubble. The most noticeable feature about these cavities is t, while some of them are of very irregular form, the great majority clearly *negative crystals* differing greatly in the development of their veral faces, but all arranged with their axes parallel to those of the closing positive crystal. As the liquids in these cavities can be heated above the critical temperature of carbon dioxide without undergoing preciable change, it is probable that they are aqueous solutions. sides the liquid-cavities, this quartz contains acicular crystals of blue rmaline (indicolite), sometimes forming matted tufts; and in addition find hexagonal plates, often 6 to 8 millimetres across, of a muscovite th tolerably wide separation of the optic axes. These muscovite ystals appear to be confined to the outer part of the quartz-crystals, hich by the symmetrical disposition of their foreign inclusions thus come exhibit a markedly zoned structure.

Now, as in the case of the Brazilian quartzes, I satisfied myself that

fractures of the Madagascar specimens made in the ordinary way show no trace of the "rippled" surfaces. Nevertheless the specimens broke in the powerful vice exhibited, when the plane of separation was along a nearly equatorial direction, remarkable examples of the "engine-turned" surfaces referred to by Brewster, the appearances being even more strongly pronounced than in the case of the Brazilian specimens.

By the kindness of Mr. Butler, I have been enabled to witness the actual operations by which these peculiar fractures are produced. It has already been remarked that the "rippled" surfaces arise when the quartz-crystals are placed in such a position in the machine that fracture takes place nearly at right angles to the principal axis of the crystal. It was found, in fact, that when crystals are placed so that the plane passing through the two steel jaws of the machine coincides with an equatorial plane of the crystal, "rippled" surfaces of fracture could nearly always be obtained. As strong pressure is applied, a series of crackling sounds is heard, and then, after the grip has been maintained for some seconds, the mass gives way, often with a loud report. It is evident that before the actual rupture occurs a number of violent strains are set up within the mass, and that under the influence of these strains it finally yields.

A study of the fractured surfaces revealed the following results:—The ridges and furrows are very much more prominent than those seen in fractured "amethysts," the height from the bottom of a furrow to the top of a ridge being sometimes as much as 0·5 millimetre, though usually it is much less than this. The width of the ridges and furrows is very varied, occasionally reaching as much as 1 millimetre, but being usually from 0·2 to 0·5 millimetre, and sometimes much less. Usually two sets of ridges and furrows can be traced, mutually intersecting and thus giving an appearance exactly resembling "cross ripple-marks" or "engine-turned" surfaces.

In some cases a fortunate fracture nearly parallel to the principal axis of the crystal enables us to study the direction in which the lamellæ (whose existence is revealed by the fracture) intersect the equatorial plane. In these cases we see a "rippled" surface, quite similar to those of "amethyst," gradually dying out at distances varying from 2 to 20 millimetres from the equatorial fractures, which are so strongly marked by ridges and furrows. These ripplings seen on vertical fractures traversing the crystal, taken in conjunction with those which are exposed in the horizontal fractures, with which they are evidently continuous, enable us to determine that the planes which they follow are really those of $R\,(100)$ and $-R\,(\bar{1}22)$.

When the ridges and furrows exposed on the fracture at right angles to e principal axis are carefully studied, two very striking circumstances e impressed on the mind of the observer. In the first place it is mani- t that the two sets of lamellæ are sometimes accurately parallel to the mbohedral faces of the crystal. But in the second place it is equally ar that these lamellæ are very often deflected from their proper direc- ns, that they assume curved and twisted forms, that they not unfrequently come merged in the ordinary lines of the conchoidal fracture, and some- es die out in an apparently capricious manner.

The curvature, distortion and abrupt dying out of the twin-lamellæ of bite, plagioclase-felspar and other minerals is a phenomenon very miliar to mineralogists, and especially to petrologists. But in quartz- stals it can easily be shown that this disturbance of the lamellæ from ir normal positions is often carried to an extreme.

This remarkable phenomenon is admirably illustrated by the section of a y beautiful "amethyst," which I owe to the kindness of Professor A. Church, F.R.S. The section is believed by Professor Church to have n one of those originally in the possession of Sir David Brewster, and it mirably exemplifies what that investigator regarded as "the most neral structure of well crystallised amethyst."[1] There is also a close reement between this amethyst and the one so carefully investigated Böklen[2] in 1883.

The section to be described is about 2·5 millimetres thick, and in linary light exhibits the lamellar structure in certain parts, by the tribution of the colouring matter, the limits between the lamellæ being rked with faint purple lines. The width of the lamellæ seldom exceeds millimetre, and is often much less. In plane polarised light the mellar structure becomes very distinctly apparent, the alternate bands pearing in violet and yellow tints, and the lines separating them being rly black, as described by Brewster. These characters remain con- nt when the section is rotated between the crossed nicols, but, when of the nicols is rotated, the colours of the lamellæ change alternately the complementary tints.

By the kindness of my colleague, Professor A. W. Rücker, F.R.S., I ve been able to place this section (which is about 50 millimetres in meter) between the large nicol prisms which the late Mr. Spottiswoode sented to the Physical Laboratory of the Royal College of Science.

---

[1] *Trans. Roy. Soc Edinb.* Vol. IX, pp. 146-152, Pl. X. f. 12.

[2] *Neues Jahrb. für. Min. &c.* 1883, Vol. I. pp. 62-73, Pl. V.

An image of the whole section could thus be thrown on a screen, show ing the distribution of the lamellæ in the minutest detail. Mr. R Chapman has obtained for me very beautiful silver-print photographs o this image, the best results being obtained when mono-chromatic (green light is employed. From the negatives thus obtained Messrs. Waterlo have succeeded in producing a block for printing by their half-tint process This, though far inferior in the reproduction of minute detail to th silver prints, will serve to illustrate the position and relations of th lamellæ in this very interesting quartz-crystal (see Plate IV.). Referrin to the key-plate (Plate III.) it will be easy to identify the structures re ferred to in the following description.

From the centre of the crystal (O) there radiate three bands of a pal yellow tint, at angles of 120°. At distances of 7, 18, and 16 millimetre from the centre of the crystal, these bands expand into sectors, (x, y, z with an angle of almost exactly 60° and having the same pale yellow tint Now, although the largest of these sectors (x) is clearly double, and con sists of right- and left-handed quartz which are superposed along the line x giving Airy's spirals, the whole of those portions of the crystal whic have a pale yellow tint show no trace whatever of lamellar structure The remainder of the crystal, however, which has the usual purple tint o amethysts, exhibits the lamellar structure in a most striking manner The sectors AOB, BOC, and COA are seen to be perfectly distinguishable the lamellæ in one sector meeting the neutral bands in the adjoining sector, when the section is viewed by polarised light. All these appear ances have been admirably described by Brewster and Böklen; but wha is particularly noticeable in this crystal is the amount of disturbance i the *position* of the lamellæ in the exterior portions of the crystal. In th centre of the crystal there is the most perfect regularity and symmetry but, as we pass outwards, curved and rippled forms make their appearance till at the outer limits of the crystal the whole of the lamellæ break u into a multitude of twisted and interrupted bands. Still more striking i the circumstance that when the lamellæ meet the three yellow sector x, y, z, they can be seen to be deflected from their former course by a angle of about 30°.

While the yellow portions (x, y, z) of the crystal exhibit the ordinar circular polarisation of quartz, the purple portions AOB, BOC, COA which are traversed by these fine lamellæ, exhibit *no trace of such circula polarisation* when studied in convergent polarised light. In the central part of the crystal, where the symmetrical disposition of the lamellæ is preserved the quartz behaves like an ordinary *uniaxial crystal*, showing the usu

ngs and black cross, while in the outer portions, where the position of the mellæ is interfered with, we find the rings and hyperbola of a *biaxial ystal*, and often of one with a considerable separation of the optic axes. here the lamellæ are much broken up and interfered with, we often find at the interference figures exhibit curious irregularities and much distor-on.

Now it is impossible not to recognise in the position of the lamellæ of s quartz-crystal a close analogy with the curious rippled fracture engine-turning") of the crushed quartzes already described. In both ke we see the tendency of the lamellæ to lose their regular and mmetrical arrangement, and to become curved, twisted and interrupted a very remarkable manner. Nor is there any difficulty in understand-g how the difference in molecular structure of the alternating lamellæ, ich makes itself apparent in equatorial sections when etched with drofluoric acid, also gives rise to the curious differences in fracture.

The distribution of colour in the remarkable amethyst we are describing nother and very suggestive indication of the peculiarities of molecular ucture in different parts of the crystal. Among the numerous very eresting observations made upon amethyst by Brewster, none is more markable than that on the effects of heat on these quartzes with mellar structure. Brewster showed that the purple colour of the ethyst can be removed by heating it, "but when the colour is removed heat, neither the veins nor their optical actions suffer any change."[1]

It is thus seen that there is no necessary connection between the mellar structure and the distribution of colour, though the latter has en clearly determined by the former. That slight changes in the state oxidation of the iron and manganese, which appear to be present in ry minute quantities in these amethysts, give rise to the yellow and rple tints, is almost certain. The way in which such changes take ce in mixtures of silicates through the action of changes of temperature even in consequence of passage of light through them, is well known m experiments on topazes and other minerals, and also on artificial cates like window-glass. That these chemical changes should be ermined and controlled by the molecular structure of the crystals, is perfect accordance with what we know from the study of the etched faces, weathered faces, and "solution-planes" of crystals. It is fectly conceivable, and indeed there are not wanting facts to support suggestion, that the distribution of colour in these amethysts has been

[1] *Loc. cit.* p. 143.

brought about subsequently both to the growth of the crystal and the development of the lamellar structure in certain parts of it.

There is one curious and seemingly anomalous circumstance which comes into prominence when these artificially fractured quartzes are compared with the so-called amethysts with natural "rippled" fracture. It has already been pointed out that in the fractured surfaces the ridges and furrows of the crushed crystals are much more pronounced than in the natural "amethysts." If the peculiar fracture in both cases be due to the existence of a lamellar structure in the crystals, it might be expected that this structure, as exhibited in polarised light, would be more marked in the crushed crystals than in the natural "amethysts." But this is certainly not the case. When a section is made from one of the crushed quartzes, immediately below the rippled surface of fracture, the lamellar structure can be faintly detected, but is far less distinct than in sections of the same thickness cut from many natural amethysts.

The following considerations will, I think, afford a satisfactory explanation of this apparent anomaly. When by Baumhauer's method, a knife-blade has been introduced into a cleavage-rhomb of calcite, so as to develop the lamellar structure parallel to $-\frac{1}{2}R(110)$, it is possible to push back the parts of the crystal over the "gliding-planes," and thus to restore the crystal to its original condition, as is seen if we examine it by polarised light. In the same way, crystals of leucite, tridymite, boracite, and other minerals lose their lamellar structure when heated to certain temperatures; the portions of the crystal appearing to move over the gliding-planes, so as to restore the original optical characters of the mass. It is perfectly possible to conceive the lamellar structure being developed in part of a crystal of quartz, in consequence of the mechanical stresses to which it has been subjected, but the natural elasticity of the quartz causing the mass to return to its normal state when the condition of strain is removed. In the case of the crystal of smoky quartz which I described on a previous occasion, the stress which produced the lamellar structure was probably applied very gradually, and was long continued; consequently we are not surprised to find its effects permanent. In the case of the artificially crushed crystals, the stress, though so intense as to lead to a more marked disturbance of the molecules, which endured during the period before rupture and determined the nature of the fracture, was maintained only for a few seconds, and when the mass was relieved by the occurrence of the rupture, the molecules might return almost to their original position. It is quite in conformity with many other observations on the comparative effects of such stresses to find that

men long continued they produce permanent results, while when they are ort and sudden their consequences are only of a temporary character.

[If we carefully study the section of amethyst-quartz which I have been scribing (see Plate IV. and the key Plate III.), we shall see that it is ilt up of two modifications of quartz, each possessing its own distinctive operties. We may assume that the quartz-crystal began to grow by the rmation of the nucleus O, and that a skeleton crystal was formed by e extension of three plates radiating from it at angles of 120°. This cleus and the plates radiating from it are composed of quartz, which has w assumed a yellow tint and shows no tendency to acquire a lamellar ructure. Between these radiating plates, however, the other modification quartz was developed, a form of quartz which shows the most marked ndency to acquire a lamellar structure, and is now of a purple tint, the lour being most intense along the bands separating the lamellæ. At a tain point, one of the radiating plates of the skeleton crystal showed a ndency to expand and form the wedge-shaped mass x, which almost mediately divided, along a nearly vertical plane, into the portions x d x_2, the former being right-handed and the latter left-handed in its cular polarisation; at a somewhat later stage in the development of the ystal the plate oz expanded into a wedge z of right-handed quartz and plate oy into the wedge y of left-handed quartz—none of these portions showing any tendency to the development of a lamellar structure. e plane which separates x from x_2 is evidently not absolutely at right gles to the equatorial plane, and thus we get an overlapping of right- nded on left-handed quartz giving rise to Airy's spiral along the band

Let us now turn our attention to the sectors which lie between the plates d wedges of yellow, non-lamellar quartz. These are composed of quartz ich is now of a purple tint and exhibits the most striking tendency to sume the lamellar structure. It is evident, from the way in which the mellæ meet one another, that the purple quartz really forms the three ctors AOB, BOC, COA, each of which is divided into two portions by the diating plates that eventually expand into wedges. Now, in the central rts of the crystal, the most beautiful regularity and symmetry is maintained in the disposition of the lamellæ, but as we proceed outwards rturbations and minute ripplings begin to make their appearance, and ese increase in number and complexity as we approach the edge of the ction. What is most remarkable, however, is the fact that the lamellæ ich were parallel to the yellow plates, are at once deflected from their rmal position when the latter expand into wedges—the amount of the

deflection reaching in some cases 30°. All of these phenomena can b clearly followed in the photograph of which Plate IV. is a reproductio and in the key Plate III.

A question which naturally suggests itself when we study this interest ing crystal is that of the period at which the lamellar structure wa developed in what is now the purple quartz. Are we to regard th lamellæ as arising in the quartz at the time of its deposition, or have the been developed long subsequently to the formation of the crystal Although most of the accidental cracks which traverse the crystal, and ar well seen in the photograph, are clearly of later date than the develop ment of the lamellar structure, there are one or two which seem to me t have influenced the position and arrest of the lamellæ. If this be th case it affords a clear proof that, as in calcite, felspar and other minerals the lamellæ of this amethyst have been developed subsequently to th formation of the crystal.

It is conceivable that the remarkable disturbance in the position of th lamellæ of this quartz-crystal originated during the growth of the crystal when the quartz, which is now of a purple tint, was confined between th growing wedges of the quartz, now exhibiting a yellow tint. It is, how ever, equally possible that in consequence of the expansion and contrac tion of the whole mass and of stresses produced by external forces on th crystal long after its complete growth, the lamellæ were forced fro their normal position and came to acquire their irregular distribution. believe the balance of probability, considering what has been proved i analogous cases, is in favour of the latter view.

I cannot help thinking that the development of the purple tint, its con centration in the neutral bands between the lamellæ, and the acquiremer by the three plates and wedges of their yellow tint, must be regarded a due to actions going on after both the growth of the crystal and th development of the lamellar structure in certain parts of it.

It is, I believe, impossible to maintain with Brewster that th laminated quartzes (amethysts) constitute a distinct group, as distinguishe from quartzes without lamellar structure. The observations DesCloizeaux and many other mineralogists prove that many quartz crystals include portions in which a lamellar structure is developed. Bu the study of forms, like that described in this paper, point to the con clusion that there is a curious kind of dimorphism in the mineral. Ther is a variety of quartz, which we may designate as *stable* quartz, which ma be right-handed or left-handed in its circular polarisation, but show no tendency to assume the lamellar structure. On the other hand, the

another type of quartz, which we may call *unstable* quartz, in which mechanical stresses at once develop a lamellar structure. Both of these varieties may be, and in many cases certainly are, included in the same crystal, the relations of the portions of the crystal composed of either type being very variable, but always apparently governed by the symmetry of the crystal. Both of these varieties may be perfectly colourless, but, when coloured, the stable quartz tends to assume yellow tints and the unstable quartz to acquire a purple colour. Further than this, it may be noticed that the purple colouring matter tends to be concentrated in the bands separating the alternating lamellæ of right- and left-handed quartz.

When the lamellæ of right- and left-handed quartz are of sufficient breadth, then overlapping gives rise to Airy's spirals in convergent polarised light; but when, as in the example before us, the lamellæ are very narrow, the circular polarisation is entirely neutralised and quartz behaves in convergent polarised light like an ordinary uniaxial mineral; where, however, as in the outer part of the crystal described, the lamellæ are much disturbed and distorted, the quartz assume the characters of a biaxial mineral, the interference figures in some cases showing very singular anomalies.

The interesting researches of Des Cloizeaux[1] Tschermak,[2] Melville, and Sundgren,[3] have shown that cinnabar crystals are sometimes built up of alternating lamellæ of right- and left-handed material, and in this mineral we appear to have a remarkably parallel series of phenomena to those which we have been discussing in the case of quartz. We do not propose to enter upon the interesting theoretical questions raised by Mallard and Wyrouboff as to the dependence of the circular polarisation in such crystals on the existence of binary and ternary arrangements of biaxial plates of ultramicroscopical dimensions.

Summary of Conclusions.

1. There appears to be a curious kind of *dimorphism* presented by quartz—in virtue of which the two forms of the substance exhibit very different properties in relation to their behaviour when subjected to mechanical stresses.

2. One of those forms of quartz, which we have designated *stable*

---

[1] *Comptes Rendus*, Vol. XLIV. p. 876.

[2] *Min. u. Petrog. Mitth.* Vol. VII. 1886, pp. 361-2.

[3] *Bulletin of the U. S. Geol. Surv.* No. 61, 1890.

quartz, shows no tendency to assume a lamellar structure. This stabl quartz may be either right-handed or left-handed in its circular polarisa tion ; it is often quite colourless, but when coloured shows a tendency t assume yellow tints.

3. The other form of quartz, which we distinguish as *unstable quart* constantly shows a tendency to have a lamellar structure developed in i The lamellæ, which in their thickness vary between wide limits, are com posed of right- and left-handed quartz, arranged alternately. The unstabl quartz, though often colourless, shows a great tendency to assume th purple tints of amethyst.

4. The difference in the molecular structure of these two forms quartz may be demonstrated in three different ways :—

(*a*) When thick sections, cut equatorially, are examined betwee crossed nicols, the alternate bands of the lamellar quartz polarise in pa grey tints ; or in some cases in complementary tints of a low order i Newton's scale ; the boundaries between the lamellæ sometimes appea nearly black.

(*b*) When faces or cut sections of quartz crystals are etched wit hydrofluoric acid, the forms and distribution of the etching figures affor a ready means of distinguishing between the lamellar and non-lamella quartz.

(*c*) When the crystals are broken, a curious rippling of the surfac of fracture is very characteristic of the lamellar quartz, and when two se of crossing lamellæ are present, a very striking appearance, similar to th "engine-turning" of watches, is exhibited.

5. The lamellæ of quartz are normally parallel to R (100) and $-$ (122). Though sometimes very symmetrical in their position and co stant in their direction, they at other times display a great tendency to b diverted from their normal positions, being deflected through angles 30° or upwards, and not unfrequently bent into curves or twisted to extraordinary extent. The dependence of these perturbations in th position of the lamellæ on the mechanical forces to which the crysta have been subjected is sufficiently obvious.

6. When the lamellæ are of sufficient width they give rise, by the overlapping, to the phenomenon of Airy's spirals, when viewed in co vergent polarised light. But when the lamellæ are very thin, the resu is that the circular polarisation of the quartz is completely neutralise In such cases quartz is found to behave like an ordinary uniaxial miner without circular polarisation. When the fine lamellæ are greatly be and disturbed we find that the quartz crystals give the interference-figur

biaxial substance; and where excessive changes in the position of the llæ have occurred, very abnormal and unsymmetrical interference es result.

Many quartz crystals are composed of portions of stable quartz com- d with unstable quartz. The proportions and relative positions of e two forms of quartz in the crystals vary greatly in different cases, always show some relation to the symmetry of the crystal.

When quartz crystals, composed wholly or in part of unstable tz, are subjected to great mechanical stresses, the lamellar structure duced in their mass; under the influence of this molecular distur- e the fractures often show very marked ridges and furrows and some- s the complicated appearance of "engine-turning." The relief of the sses by fracture, however, permits of the almost complete recovery of rystal from the molecular disturbance, under the influence of which acture took place; and optical tests show only a slight residual of the effects produced by the pressure.

When chemical changes, resulting in the production of colour, place in a quartz crystal, not only do we find the stable and unstable z assuming different tints, the former yellow and the latter purple, he distribution of the colour in the unstable quartz appears to be rmined to some extent by the lamellar structure. Thus we find the le tint concentrated along the lines separating the lamellæ, and the liar structure of the quartz is rendered visible in ordinary light.

By heating, the colour of both varieties of quartz may be de- ed, while the peculiarities of molecular structure remain.

On some examples of Cone-in-Cone Structure.

By Prof. Grenville A. J. Cole, F.G.S.

[Read April 12th, 1892.]

PROBABLY everyone who has considered the arrangement of th constituents of an aggregate composed of radially grouped fibres h realised that the individual fibres are conical or pyramidal in form, the apices meeting in the centre of the aggregate. In a coarse example of th mode of crystallisation, such as the calcite concretions in the magnesia limestone of Durham, this conical form of the constituent crystals is ve easily seen; the cones cleave across, where composed of a cleavab mineral, showing that the particles composing them have the sam orientation within the limits of the cone, and that each cone, in fact, is crystal, bounded ultimately by contact with its neighbours. It shoul therefore, be polygonal in cross section, if neighbouring cones ha developed equally so as to meet it.

Such groupings of crystallites to form crystalline cones are famili features of the growth of spherulites in igneous rocks. Often the spherulites are developed from a surface, so that they form or hemispheres, their bases against the originating surface. Where number of points on a surface of cooling serve as starting-points radial groups of crystalline fibres, conical structure, rather than tr spherulitic growth, predominates, and the interstices between the con or bunches of fibres, become filled up by similar growths on a smal scale. A zone of fibrous matter thus forms from the originating surfa outwards, terminating in a mammillated exterior when conditions favoura to crystallisation no longer prevail.

Should, however, a second surface, say a crack in the consolidat rock, lie parallel or approximately parallel to the surface from wh crystallisation has spread, the conical groups of fibres will terminate their outward growth against this second surface, and flat-topped co of crystallisation will take the place of hemispheres or mammilla

gregates. A beautiful illustration of this appears in Mr. Rutley's awing of an obsidian from Pilas, Mexico.[1]

The connection between radial crystallisation and cone-in-cone structure, as, it is scarcely necessary to say, fully grasped by Dr. Sorby in 1859.[2] e compared cone-in-cone structure to oolitic grains in which fibrous ystallisation had taken place entirely on one side of the centre of aggre- ion, and wrote, "by the mutual interference of contiguous groups, d of others contained within themselves, there was formed a mass of egular cones enclosing other cones." He concluded that "this struc- e is one of the peculiar forms of concretions, formed after the deposi- n of the rock in which they occur, by the crystallisation of the carbonate lime and other isomorphous bases."

Mr. John Young,[3] in his last letter on this subject, seems still to ribute to faulty observation or to badly preserved specimens the cases re the apices of cones have been recorded as pointing in towards one ther. But previously he has been careful to restrict his theory of the chanical origin of cone-in-cone to the specimens that he had selected description[4] in 1885,[5] so it may be taken for granted that another ory is required to account for such cases as Mr. Gresley has brought ward,[6] where concretions have cone-in-cone structure over all their aces, the apices of the cones being directed radially inwards. A ilar example occurs in my own collection, and others are described by f. Newberry.[7]

As far as I am aware, Mr. Gresley's paper in 1887 is the most distinct l valuable addition to our knowledge of cone-in-cone since the re- rches of Dr. Sorby, although the author confesses that the structures erved are very complex, and that he himself has no explanation to ance. But in his figures 1 and 2 he shows the serrated surfaces ned where the wall of one cone approaches that of another lying within These are well known when visible to the naked eye, but are, as Mr. sley showed, worthy of microscopic examination.

When a specimen has been broken, and one cone can be pulled away

---

[1] *Quart. Journ. Geol. Soc.* Vol. XLVII. (1891), p. 531 and Pl. XVIII., Fig. 3.

[2] "On the origin of 'cone-in-cone'." *Brit. Assoc Rep.* for 1859, pt. 2, p. 124.

[3] *Geol. Mag.* 1892, p. 139.

[4] *Geol. Mag.* 1886, p. 140.

[5] *Ibid.* 1885, p. 283.

[6] "Notes on 'Cone-in-Cone-Structure," *Geol. Mag.* 1887, p. 17. Also *Quart. rn. Geol. Soc.* Vol. XLI., Proceedings, p. 110.

[7] *Geol. Mag.* 1885, p. 560.

from a larger one which has surrounded it, the inner surface of the latte is seen to be more or less regularly ridged, the ridges forming little pro jecting platforms approximately in planes parallel to the base of the hollow cone. This structure is all the more conspicuous in specimens that have become washed and weathered. The microscope shows us that in such a system of cones fitting one within the other, the cones are separated by an interval of fine muddy material, which occupies the space between the serrations of one cone and the smooth outer surface of that within it (fig. 1). The successive cones may vary in steepness; and horizontal sections across them show that they are not so regularly developed as might be supposed, portions of cones embracing portions o other cones being at least as common as complete cones fitting into other (fig. 2). Their horizontal section reminds one, indeed, of the perlitic structure. Whether this conical subdivision of the mass is due to a tendency to crystallisation, or is merely a type of jointing, may be a matter of opinion; but I am strongly inclined to connect it with the pro cess of crystallisation of which we have evidence in so many specimens.

Following out the considerations put forward at the beginning of this paper, we may conceive that crystallisation of one constituent of the rock commences at a number of points *on the surface of a bed, or in the interio of a concretion*, the growth radiating outward from these points and tending to form a cone above each, comparable to those figured by Mr. Rutley, and so familiar to students of spherulitic rocks. But there are materials presen in the rock which have no such tendency to crystallise; these are forced aside by the crystallising material. though they cannot be entirely got rid o or extruded from the growing cone (fig. 3). As in chiastolite, their presence gives us a clue to the mode of growth and structure of what otherwise would have been a homogeneous mass. We thus learn that the cone i itself built up of a multitude of cone-shaped bodies, reminding one of the primitive bricks in Haüy's theory of crystal-growth. A conical aggregate of crystallites thus succeeds in developing above a point; additional crystallising material creeps towards it laterally and along its surface from above or from below; the primary acicular crystal or group o crystals tends to thicken by these additions; but a quantity of the matrix becomes included, and is pressed and arranged against the surface of the first developed cone. The forces of crystallisation prevail over it, and give it a fairly symmetrical arrangement, and a new sheath to the primary cone is developed, divided from the latter by a film of matrix. The inner surface of this sheath, or outer cone, is ridged, showing serrations i section, since the sheath is built up, as already hinted, of minute conic

gregates comparable to the main structure.[1] The top of the little ridges
platforms running round the interior of the sheath is formed by the
on of the tops of these subsidiary cones; on the outside of the sheath
ir conical surfaces unite to form a new smooth exterior like that of the
t developed cone (fig. 1). Sheath after sheath, complete or partial, thus
elops round the primary cone, the whole structure also growing upwards,
il it is cut short by reaching the other surface of the bed or the surface of
concretion in which it has been able to originate. Although so much of
matrix is thrust aside, an immense quantity of foreign material remains
luded in the crystalline aggregates; so that the cones are comparable
the rhombohedra of the Fontainebleau sandstone, and their extinctions
continuous crystalline bodies are generally masked. Workers among
products of contact metamorphism will know how a well marked
stal of staurolite or andalusite will be almost unrecognisable in section,
ng to the small proportion that the crystallised material bears to the
trix ophitically caught up in it; and this fact must be borne in mind
considering cone-in-cone structure as essentially crystalline. But a
cimen in the collections of the Royal College of Science for Ireland
me the first assurance that this view was a correct one. It was
en to Prof. Jukes by Mr. Beckett of Wolverhampton, and comes
kstless from the Coal Measures of that area. Cleavage-surfaces can be
ected in it, glancing like those of an ophitic igneous rock when the
cimen is turned about in the hand. The material is calcite, with a
ce of ferrous carbonate, and the cleavage-surfaces are inclined in
ious azimuths to the axes of the cones. Crystallisation appears so
rough in this specimen as to at once ally the cones to the radial
es of the Durham concretions. A section shows corresponding optical
tinuity of the material, extinction taking place when the axes of the
nes are parallel or perpendicular to the diagonals of the nicols. The
sence of unextinguished crystalline impurities renders this observation
y approximate; but the continuity of extinction in the main mass
oves the crystalline character of the cones, while it seems highly
bable that the principal axis of the calcite constituent lies parallel to
ir axis of form.

The building of conical crystalline fibres on a large scale by the aggre-
ion of a multitude of small cones, each with its successively added
ts or partial envelopes, is illustrated by the microscopic structure of
f. Jukes's specimen. Sufficient foreign matter was present to mark

[1] Cf. W. S. Gresley, *Geol. Mag.* 1887, p. 19.

the several coats. But this may be also quite a common mode of growt in homogeneous materials, the cones only becoming revealed to us, an becoming separable, by the arrangement of the matrix when it is presen The specimens that I have had to hand during the preparation of thes notes consist of carbonates of lime and iron: in one of them quart grains form the bulk of the impurity, standing out like fine sand afte treatment of the rock with acid. But cone-in-cone may occur in othe materials, wherever radial crystallisation struggles with an uncrystallisin matrix. The so-called "Beef," or fibrous calcite, of the Purbeck an other English strata, forms the best link I am acquainted with betwee cone-in-cone and ordinary fibrous crystallisation.

Very similar structures may be seen on the surfaces of coal, as in som blocks from Wigan lately pointed out to me by the Rev. Maxwell Clos It is possible that these are cases where the impurity is altogether ou of proportion to the crystallising material, the latter forming the meres films, since films of calcite still cling in places to the surface of th carbonaceous cones. I am also much indebted to Mr. G. W. Butler, B.A F.G.S., for several specimens lent me in the course of the present obse vations.

Fig. 1. Vertical section of cone-in-cone, the crystallising materi consisting mostly of ferrous carbonate. Portions of two conical serie are seen, the apices directed downwards. The mode in which coat belonging to adjacent cones meet and fit against one another can be see in the left hand half of the drawing. × 8.

Fig. 2. Horizontal section of cone-in-cone, more argillaceous than the ove, showing section of cone, with smaller cones and partially developed nical coats, indicated by the dark and somewhat irregular lines within × 12.

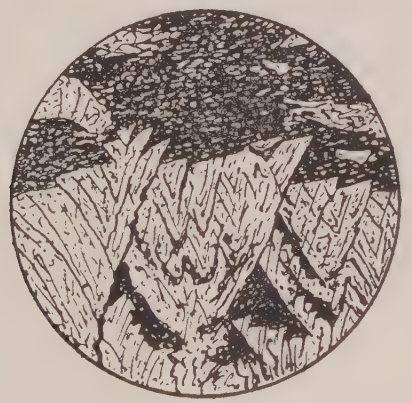


Fig. 3. Vertical section of part of the same specimen as that used in g. 2, showing cones developing in the argillaceous matrix, which has ly in part been forced to assume a definite arrangement. × 18.

Note on a Crystal of Tourmaline.

By W. J. Lewis, M.A., F.C.S.

Professor of Mineralogy in the University of Cambridge.

[Read June 14th, 1892.]

MY friend, Mr. A. T. Karslake, sent me recently a parcel of crystal from Ceylon, amongst which was a brown tourmaline showin the very rare face $z = (\bar{1}22)$, (first recorded by Haüy), on whose exist ence so much doubt has been thrown. The crystal is about $\frac{1}{2}$ inc across, and about $\frac{1}{4}$ inch in the direction of the axis, and shows well th hemimorphic development. At the analogous pole are $r\{100\}$ an $z\{\bar{1}22\}$, both largely developed, also $o\{111\}$, $e\{110\}$, $s\{\bar{1}11\}$, $\{\bar{3}22\}$.

At the antilogous pole are $\{\bar{1}00\}$ very large, and $\{1\bar{1}0\}$ very smal The prism faces are $b\{2\bar{1}\bar{1}\}$ and $a\{10\bar{1}\}$.

The faces z are triangular and give a broken reflection such as migl be obtained from a thin plate of ice resulting from the freezing togeth of several plates which had started simultaneously at differe points on the surface of smooth water. The means of the measuremen with naked eye of the angles in two zones are or 27° 30′, oz 27° 35′ (t two readings being 27° 58′ and 27° 18′), os 46°·6′, $111 : \bar{3}22 = 68°{\cdot}4$ and ob 89° 58′.

Note on a peculiar occurrence of Galena.

By J. Stuart Thomson.

[Read June 14th, 1892.]

SOME time ago I was informed that galena was being obtained in a sandstone quarry at Aimville, about two-and-a-half miles north of Dirknewton, which had been recently re-opened for the purpose of supplying building material in connection with the extension of the Harperrig Reservoir, belonging to the Edinburgh Water Trust. As I saw no likelihood of my soon being able personally to visit the spot, I mentioned the fact to my friend, Mr. Alex. Lumsden, M.E., who I knew had sometimes occasion to pass near the locality, at the same time telling him that I did not attach much importance to the alleged occurrence, and that I did not expect that it would be of such interest as to be worthy of a special visit. Subsequent investigation showed, however, that I was mistaken, and as the mode of occurrence of the mineral is so unusual, some account of it may not be without interest.

Up to the present time I have been unable to visit the quarry personally, so that the following account is mainly based on notes made by Mr. Lumsden, who has kindly put them at my disposal.

The special interest in this instance lies in the fact that the galena only occurs as isolated loose crystals, in cavities in the otherwise solid sandstone. The cavities are small—not larger than a pigeon's egg, and more frequently not bigger than a hazel nut—and are filled with a fine soft clay in which the crystals lie imbedded. There is never more than one crystal found in a cavity, and not unfrequently the cavities contain no crystals, or are, as the quarrymen term them, "barren." The cavities are scattered over the whole section which is exposed, and do not appear to be disposed in any particular zone; they are by no means common, in fact they are of rather rare occurrence. The rock itself is situated among the upper members of the Old Red Sandstone, if it is indeed not a part of the Old Red itself. The strata immediately overlying the sandstone are somewhat vitrified, apparently by the whinstone of the neighbourhood.

Note on a Crystal of Tourmaline.

By W. J. Lewis, M.A., F.C.S.

Professor of Mineralogy in the University of Cambridge.

[Read June 14th, 1892.]

MY friend, Mr. A. T. Karslake, sent me recently a parcel of crystal from Ceylon, amongst which was a brown tourmaline showin the very rare face $z = (\bar{1}22)$, (first recorded by Haüy), on whose exis ence so much doubt has been thrown. The crystal is about $\frac{1}{2}$ inc across, and about $\frac{1}{4}$ inch in the direction of the axis, and shows well th hemimorphic development. At the analogous pole are $r\{100\}$ an $z\{\bar{1}22\}$, both largely developed, also $o\{111\}$, $e\{110\}$, $s\{\bar{1}11\}$, $\{\bar{5}22\}$.

At the antilogous pole are $\{\bar{1}00\}$ very large, and $\{\bar{1}\bar{1}0\}$ very smal The prism faces are $b\{2\bar{1}\bar{1}\}$ and $a\{10\bar{1}\}$.

The faces z are triangular and give a broken reflection such as migl be obtained from a thin plate of ice resulting from the freezing togeth of several plates which had started simultaneously at differe points on the surface of smooth water. The means of the measuremen with naked eye of the angles in two zones are or 27° 30′, oz 27° 35′ (t two readings being 27° 58′ and 27° 18′), os 46°·6′, $111 : \bar{3}22 = 68°{\cdot}4$ and ob 89° 58′.

Note on a peculiar occurrence of Galena.

By J. Stuart Thomson.

[Read June 14th, 1892.]

SOME time ago I was informed that galena was being obtained in a sandstone quarry at Aimville, about two-and-a-half miles north of Kirknewton, which had been recently re-opened for the purpose of supplying building material in connection with the extension of the Harperrig Reservoir, belonging to the Edinburgh Water Trust. As I saw no likelihood of my soon being able personally to visit the spot, I mentioned the fact to my friend, Mr. Alex. Lumsden, M.E., who I knew had sometimes occasion to pass near the locality, at the same time telling him that I did not attach much importance to the alleged occurrence, and that I did not expect that it would be of such interest as to be worthy of a special visit. Subsequent investigation showed, however, that I was mistaken, and as the mode of occurrence of the mineral is so unusual, some account of it may not be without interest.

Up to the present time I have been unable to visit the quarry personally, so that the following account is mainly based on notes made by Mr. Lumsden, who has kindly put them at my disposal.

The special interest in this instance lies in the fact that the galena only occurs as isolated loose crystals, in cavities in the otherwise solid sandstone. The cavities are small—not larger than a pigeon's egg, and more frequently not bigger than a hazel nut—and are filled with a fine soft clay in which the crystals lie imbedded. There is never more than one crystal found in a cavity, and not unfrequently the cavities contain no crystals, or are, as the quarrymen term them, "barren." The cavities are scattered over the whole section which is exposed, and do not appear to be disposed in any particular zone; they are by no means common, in fact they are of rather rare occurrence. The rock itself is situated among the upper members of the Old Red Sandstone, if it is indeed not a part of the Old Red itself. The strata immediately overlying the sandstone are somewhat vitrified, apparently by the whinstone of the neighbourhood.

The crystals are mostly simple cubes, but a few are modified by th octahedron and occasionally twins are found; the crystals are small none that I have seen exceeding half-an-inch in length.

Professor Heddle records finding crystals of galena in the Old Re Sandstone, in the island of Rousay, Orkney; the galena occurring i small nests of crystals—cubo-octahedra —without any connecting string

On Geikielite, a New Mineral from Ceylon.

By A. Dick.

Communicated by J. J. H. Teall, F.R.S.

[Read June 14th, 1892.]

THE mineral which forms the subject of this communication came from the gem mines of Rakwana, Ceylon, and was brought to England by Mr. Joseph Baddeley, who, while superintending operations there, had formed a collection representative, it was believed, of almost every kind of pebble to be found at the works. This collection Mr. Baddeley, on his return home, submitted to Mr. Pringle at the Museum of Practical Geology, London. In looking, from time to time, over the collection, Mr. Pringle had occasion to take the specific gravity of some of the specimens. Amongst those so tested were certain pebbles the sp. g. of which was found to be about 3·98. This result, combined with their other physical characters, having rendered it impossible for Mr. Pringle to assign them to spinel, ilmenite, or other species with which he could compare them, he handed the pebbles over to me for chemical analysis. They weighed about 2 oz. in all, and varied in size from that of a pea to that of a hazel nut. After breaking several I selected for analysis that one which gave the most brilliant cleavage and which seemed nearly quite pure when small fragments were examined under the microscope. It was almost absolutely free from a more transparent yellow mineral which was afterwards obtained in sufficient quantity (0·3 gram) for analysis, and proved to be rutile.

Qualitative analysis showed the new mineral to consist of titanic acid and magnesia, with a small amount of protoxide of iron. The quantitative analysis was made by fusing the finely powdered mineral with excess of bisulphate of potash. The fused mass was completely dissolved by cold water, and the titanic acid precipitated by boiling. It was filtered off and again re-fused with bisulphate of potash to separate any remaining iron or magnesia, again precipitated by boiling after adding a little sulphite of soda, filtered, washed, ignited and weighed. The iron was precipitated

from the mixed filtrates after peroxidising with nitric acid, by ammonia ammonium chloride having been added to retain the magnesia in solution The oxide of iron was filtered off, washed, ignited and weighed. It still retained a little titanic acid, which, however, was lost by accident.

The magnesia (after concentration of the filtrates) was precipitated by phosphate of ammonia, filtered off, washed with ammoniacal water, ignited and weighed.

The following figures show the results of the analysis :—

Titanic acid	67·74
Magnesia	28·73
Protoxide of iron	3·81

Theoretically, titanate of magnesia should consist of—

Titanic acid	66·66
Magnesia	33·33

taking the atomic weight of titanium as 48, and that of magnesium as 24. The mineral contained no lime.

These figures show clearly the nature of the mineral. It is the magnesian analogue of perofskite (titanate of lime), which it much resembles in colour and lustre, though it differs from it in optical properties. After consultation with Mr. Pringle, we agreed to call the miner Geikielite, after Sir Archibald Geikie, the Director General of the Geological Survey. The principal characters are as follows :—

Crystalline Form.—Unknown.

Hardness.—About 6. It scratches orthoclase with difficulty, and does not scratch quartz.

Specific Gravity.—3·98 to 4.

Lustre.—Metallic-adamantine on cleavage face.

Cleavage.—Has one brilliant cleavage and an imperfect one nearly at right angles to the former, in other directions hackly-conchoidal suggestive of ilmenite. The mineral is brittle.

Colour.—Blueish black or brownish black, according to the manner in which the light falls upon the mineral. Thin fragments under the microscope transmit a peculiar purplish red light.

Refractive Index.—Owing to the opacity of the mineral and the dark colour of the thinnest fragments it is difficult to form a correct opinion but the index seems to be high.

Double Refraction.—Very strong. Apparently between that of sphene and rutile. A great many of the thin flakes show between crossed nicols in convergent polarised light a uniaxial figure, the axis just outside the field of view. The character of the double refraction is negative.

Action of Acids.—In fine powder, slowly decomposed by hot strong drochloric acid, the titanic acid separating while the magnesia and iron ss into solution. The iron appears to be entirely in the state of pro- ide. The mineral is also decomposed by hydrofluoric acid even in the d in the course of a few hours if finely powdered.

Before the Blowpipe.—Infusible alone. With microcosmic salt gives characteristic reaction of titanic acid. The small amount of iron arcely interferes with these reactions. The magnesia does not seem to ert any influence whatever.

Rutile.—All the rolled fragments of the mineral which I have examined der the microscope show, in addition to the characteristic plum-coloured gments, here and there pale yellow and more transparent fragments sembling rutile. From one of the pebbles containing more than usual this yellow mineral I picked out under the microscope 0·3 gram analysis. It yielded 99·2 per cent. titanic acid, and gave a positive iaxial figure in convergent polarised light, so that there is no doubt the ompanying mineral is rutile. Possibly Geikielite may be found in neral collections amongst the dark coloured specimens of rutile, from ich it will easily be distinguished by the action of acids.

On Baddeleyite (native zirconia), a new Mineral, from Rakwana, Ceylon

By L. Fletcher, M.A., F.R.S.

Keeper of Minerals in the British Museum.

[Read October 25th, 1892.]

SHORTLY after the Meeting of June 16th, at which Mr. Dick gave th description of the characters of Geikielite,[1] Mr. Joseph Baddeley, wh had brought the specimens from Rakwana (or Rackwanné) (80°40′ E 6°25′ N., in the District of Kollonnagam, Ceylon), courteously offered present one of them to the British Museum for preservation in the Miner Collection: the rest of his small store of eight or nine stones, picked o by him from a heap of other dense pebbles, he required for sending samples to those friends in Ceylon whom he wished to interest in search for further material.

In scrutinising the individuals of this small store with the view selecting the best illustration of the characters of the new mineral, I r marked that one of the fragments differed from any pebble of Geikieli previously noticed in presenting a number of crystal-faces, and on clos examination saw that it really belonged to some other kind of mineral.

The fragment weighs a little over 3 grams, and is 10 mm. long, 12 m broad, and 8 mm. thick: it is iron-black in colour and opaque: its lust is from submetallic to subresinous, and on some parts is splendent: its hardness (6·5) it lies between adularia and quartz: it is brittle: t fracture is subconchoidal to uneven: the streak is brownish-white. T loss of weight in distilled water at 19¾°C. corresponds (neglecting corrections) to a specific gravity of 6·025. In general aspect the mine is not unlike columbite.

Morphological Characters.

The form is illustrated in Fig. 1. There is only one well develop zone: it consists of two large parallel pinakoid faces a and $\bar{a}$, a narr pinakoid face, b, perpendicular to the former, and three prism-fa m, $\bar{m}$, $\bar{m}'$, having very different dimensions: the specimen shows evide

[1] Page 145.

fracture at the part where the faces $\bar{b}$ and m' would be expected to be resent. Of the original crystal, only two other visible faces d and δ survive: ney form a small re-entrant angle of which the edge is parallel to the ce $\bar{a}$. Most of the above faces are far from truly plane: the images tained from $\bar{m}$, b, and δ with the δ-eyepiece of a Fuess-goniometer e fairly definite, but those from a and $\bar{a}$ have each a range of $2\frac{1}{2}°$, and ose from m and $\bar{m}'$ a range of $1\frac{1}{4}°$: d gives no image at all.

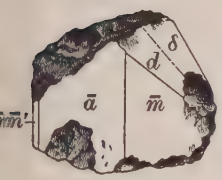


Fig. 1.

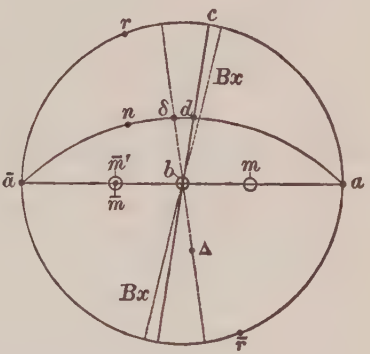


Fig. 2.

During the measurement of the zone $[\bar{a}\ d\ \delta]$ with the above eyepiece, n image was obtained from the uneven part between $\bar{a}$ and d which rresponded to a minute face having the position indicated by the pole n Fig. 2). Similarly, during the measurement of the zone $[b\ \delta]$, an image as obtained from a broken part of the crystal which corresponded to a inute face having the position indicated by the pole Δ. Further, after small piece had been broken off for the purpose of optical examination, ne part of the fracture gave an image corresponding to a plane having ne position indicated by the pole $\bar{r}$; and another image almost exactly 80° distant from the former, obtained from the broken part at the other de of the crystal, shows that this position is not an accidental one.

There is also a fair cleavage parallel to the face b.

Notwithstanding the wide range of the images from the faces in the ell developed zone, the probable perpendicularity of the faces a and b sufficiently indicated, and there is a manifest symmetry of the prism-ces relative to those perpendicular planes: the most satisfactory images the zone correspond to an angle of about 44° between the faces $\bar{a}$ and : though it would be difficult to say directly from the measurements emselves that the true angle is not 45°, and measurement with a contact-

goniometer gave a result even as high as 47°. The only other visible face of the original crystal, d and δ, are likewise far from satisfactory, d itself being too dull, as already mentioned, to give any image at all: still their aspect is such as to suggest that they are both real faces, in which case it would appear that the fragment is composite, and that the re-entrant angle $d\,\delta$ is probably a result of twinning about the face $\bar{a}$. The correctness of this interpretation gains support from the following facts:—

(1.) By reason of the weathering of the specimen, the existence of the "junction-plane" can be traced on other parts of the fragment, where the twinning is not otherwise evident.

(2.) The positions of the faces d and δ are consistent, as nearly as the measurements can be relied upon, with symmetry relative to a plane parallel to a.

(3.) The minute fracture-face Δ, unimportant in itself, is equidistant with δ from the face b, and can be accounted for as a face of the second individual.

With this interpretation we have:—

System:—Monosymmetric.

Elements:—$a : b : c = 0{\cdot}9768 : 1 : 1{\cdot}0475$

$$ac = 180° - \beta = {}^{*}81°\ 20'.$$

Parametral angles:—100:110, 44° 0′; 001:101, 42° 23′; 001:011, 46° 0′.

Forms present:—a {100}, b {010}, which is also a cleavage, m {110}, d {011}.

Fracture-faces: n $\bar{1}\bar{1}1$ and r $\bar{1}02$.

Twin-plane and face of junction: a {100}.

Angles.	Observed.	Calculated.
$\bar{a}\bar{m}'$	$\left(\begin{matrix}43\frac{3}{4}° - 46\frac{3}{4}° \\ \text{Best about } 44°\end{matrix}\right)$	*44° 0′
$\bar{m}'\bar{b}$	$\left(\begin{matrix}43\frac{1}{4}° - 46\frac{1}{4}° \\ \text{Best about } 46°\end{matrix}\right)$	*46° 0′
$\bar{a}n$	57° 49′	57° 14′
$n\delta$	26° 0′	26° 46′
δd	11¼° (microscope)	12° 0′
$\bar{a}\bar{r}$	111° 42′	111° 18′
$\left\{\begin{matrix}b\delta \\ b\Delta\end{matrix}\right.$	$\left.\begin{matrix}136° 10' \\ 135° 17'\end{matrix}\right\}$	*136° 0′
$\bar{m}\delta$	54° 9′	54° 54′

The calculated angles are based on those which are distinguished by asterisks.

Optical Characters.

(*a*.) Although the specimen is itself opaque, microscopic splinters are ite clear and transparent; they are of a light yellow colour and ite homogeneous.

(*b*.) Most of them when examined in convergent polarised light, show ne portion or other of a biaxal figure: it is rare, however, to find a inter which shows both hyperbolic brushes. The apparent axial angle somewhat large: direct comparison with a flake of mica of measured al angle indicated a slightly larger axial angle for the splinter, say -75°. In none of the many splinters examined was the acute bisectrix nd to be in the centre of the field.

(c.) Where both eyes of the axial figure were simultaneously visible, e of them seemed more distinctly coloured than the other, but the erence was scarcely sufficient to fully establish any dispersion of the an lines for different colours: in other splinters, however, showing only e of the optic axes and the acute bisectrix in the field, the hyperbolic sh is in some cases distinctly blue on the convex side, in others quite istinctly red: there is never any evidence of want of symmetry rela- to the plane of the optic axes itself. These characters point distinctly nclined dispersion: and if such be really the case, and the above inter- tation of the form of the crystal is the true one, the plane of the optic s must be parallel to the small pinakoid face *b*.

(*d*.) Owing to the numerous irregular cracks which traverse it, the stal was found to be too fragile to admit of the cutting of small itely orientated plates from its fractured portions. By means of a e small fragments, however, were broken off which sufficed for the paration of plates having an orientation which was approximately wn.

(*e*.) A small cleavage-fragment was obtained having its faces parallel and an edge parallel to the vertical edge [*a m*]. The fragment was unted on a glass slide and the direction of the vertical edge indicated a scratch on the glass: the fragment was then cautiously rubbed down Mr. T. Ryley, the departmental lapidary) until it was sufficiently thin e transparent. On examination with the microscope, there was ble a series of structural lines having their common direction parallel ne scratch, and therefore to the vertical edge: the direction of extinc- was found to be inclined to them at an angle of 13°, but on which tallographic side there was nothing to determine. In convergent t no axial figure was seen.

(2.) In the same way a fragment was obtained which presented portion of the face $\bar{a}$: but in this case there was no cleavage in the desire direction, the splinter was small, showed no edge belonging to the zon $[a\,m]$, and was difficult to work: in fact, the first fragment broke u before it was thin enough for optical examination. In convergen polarised light an optic axis was visible on the extreme edge of the field while the figure indicated that the acute bisectrix was outside: as far a could be distinguished, the plane of the optic axes passed through th centre of the field.

(3.) When fragments were broken from a corner of the face $\bar{a}$ b means of a knife held perpendicularly to it, one of them was found to be a uneven plate showing a portion of the face $\bar{a}$ and fitting into the cryst in such a way as to prove that its orientation was identical with that of particular part of the fracture: the position of this part has been alread indicated by its pole $\bar{r}$. After the plate had been mounted and rubbe down, an optic axis was visible almost exactly in the centre, and the acu bisectrix on the edge, of the field: the plane of the optic axes, as near as could be distinguished, was perpendicular to the scratch which fixe the direction of intersection of the plate with the face $\bar{a}$. The hyperbol brush was in this case faintly blue on the concave side.

(*e.*) The above characters are all consistent with the crystal bein mono-symmetric, and having its optic axes in the plane of symmetr Since one optic axis is nearly perpendicular to the plane $\bar{r}$, and the acu bisectrix is inclined at an angle of 13° to the vertical edge, while tl apparent axial angle is nearly 70°-75°, it is inferred that the bisectr is on the same side of the vertical edge as the zone-circle *bd* (as shov by *Bx* in Fig. 2).

(*f.*) The double refraction is strong: its sign is negative, or in oth words the acute bisectrix is the *a*-axis of the optical indicatrix.

(*g.*) *Pleochroism.*—The splinters are pleochroic, changing from greenish yellow to brown with the plane of polarisation of the light: wh the principal plane of the single nicol is parallel to the plane of the op axes and the light is travelling approximately along the acute bisectr the splinter is yellow: in the perpendicular position of the nicol, t splinter is brown.

Vibrations parallel to the acute bisectrix are most readily, thc parallel to the obtuse bisectrix least readily, absorbed: vibratio parallel to the axis of symmetry of the crystal show intermediate abso tion.

h.) When the light which has traversed a splinter is examined with a ctroscope, no absorption-lines are visible in the spectrum.

Chemical Examination.

The above external characters not being identical with those of any known cies, it became necessary to determine the chemical behaviour: but account of the necessity of preserving the natural faces of what might sibly be a unique fragment, this was a determination requiring the cise of great caution: fortunately the chemical behaviour was such t it was practicable to determine the precise chemical nature of the eral without any appreciable injury of the specimen. The result, wever, was so unexpected, and the morphological and optical charac- s are so distinct from those of artificial crystals of the same substance, t it is necessary to give a detailed account of the observations from which conclusion as to the chemical nature is arrived at: the high specific vity and the general resemblance to columbite and samarskite had ded to point to a member of the tantalate group of minerals.

a.) *Pyrognostic Characters.*—1. A splinter ignited in the blowpipe es glows with the extreme brightness of the lime-light and becomes e white: it does not decrepitate, is quite infusible even on its west edges, and on cooling is found to retain its transparency and its on on polarised light.

2.) Heated in a glass tube closed at one end, a minute quantity of brownish-white powder gives off no perceptible fumes or vapour: its our changes to a pinkish tint.

3.) Fusion with borax or microcosmic salt in the reducing flame s a bead which is colourless, hot and cold, and in the oxidising flame ead which is yellow when hot and becomes first greenish and then ourless on cooling. In the microcosmic bead, the powder only disappears extreme slowness: a small splinter first turned brownish-grey, then owish-white, and on prolonged ignition gradually broke up and gave ull opalescent bead, colourless both hot and cold: (this excludes, ongst other minerals, samarskite, of which uranium is a normal con- uent).

4.) Fused with sodium carbonate and potassium nitrate, it gives a t brown bead, showing the absence of manganese: (this excludes, ong other minerals, columbite and tantalite, of which manganese is a mal constituent).

5.) Fused with sodium carbonate and potassium cyanide on charcoal, ives no metallic residue.

(*b*.) *Action of acids*.—The mineral, whether in small splinters or fi powder, is almost absolutely unaffected by hot strong hydrochloric, nitr or nitro-hydrochloric acids, or by cold weak hydrofluoric acid: the powde when examined with the microscope, is found to retain its origin characters even after two months' immersion in cold hydrochloric acid merely a trace of iron passing into solution. A small flake which had be boiled in strong sulphuric acid and then allowed to stand in the cold ac for two months was found to be quite unaltered: on very prolonge digestion in strong sulphuric acid, however, in a platinum crucible over Bunsen burner, the powder is gradually affected, and the material ca thus be brought, though with difficulty, into solution.

(*c*.) The fine powder is scarcely affected by fusion with caustic soda a mixture of potassium and sodium carbonates: in the latter cas however, treatment of the fused mass with water and hydrochloric ac extracts an appreciable proportion of iron, and the insoluble residue then perfectly white in colour. The mineral is gradually brought in a soluble form by fusion with potassium bisulphate.

(*d*.) Owing to the small amount of available material, the qualitati examinations were made to a certain extent quantitative.

36·8 milligrams of the powdered mineral, dried at 112° C., still weigh 36·65 milligrams after exposure to a low red heat, and 36·4 milligra after subjection to the full heat of a gas-blowpipe: it thus appears pro able, having regard to the smallness of the change, that there is appreciable proportion of volatile matter: the ignited powder was da brown when hot and brownish-red when cold.

After fusion for nearly three hours with potassium bisulphate, the p duct was found to be completely soluble in cold water, thus excluding possibility of the mineral being a tantalate or niobate.

The solution still retained its limpidity even after long boiling: th excluding most compounds of titanic acid.

Hydrochloric acid gave no precipitate, and sulphuretted hydrogen o a small precipitate of platinum sulphide, which was found to be fu accounted for by the loss of weight of the crucible in which the fus had taken place.

After removal of the excess of sulphuretted hydrogen, oxidation, addition of a large proportion of ammonium chloride, ammonia th down a white (faintly tinged with yellow or light brown) bulky gelatin precipitate; this was dissolved in hydrochloric acid and the precipita repeated: after expulsion of the ammoniacal salts from the filtra ammonium oxalate and ammonia and sodium phosphate gave no ind tion of the presence of calcium or magnesium.

The ammonia precipitate was again dissolved in hydrochloric acid and solution evaporated to dryness on the water-bath: the residue was all in volume, of a yellow colour, and consisted of gelatine-like flakes dich had no action on polarised light: on treatment with water the flakes, dich were not easily wetted, disappeared, but the solution was incomplete, there was a slight opalescence as if due to a powder in a state of remely fine division: it was found that this disappearance was less idy the longer the heating on the water-bath was continued: the whole the material, however, passed through the pores of filter-paper. After addition of hydrochloric acid and warming, the liquid became perfectly ar, and remained so on cooling: a strong cold solution of caustic potash ve a white gelatinous precipitate which seemed quite as bulky as that ained with ammonia: no base could be detected in the filtrate. The cipitate was again dissolved in hydrochloric acid, the solution concentted, and barium carbonate added in the cold: after removal of the ium the material was again found with the precipitate, while no trace it could be detected in the filtrate. The ammonia precipitate was now ed (whereupon it contracted enormously, and became brown and wax-), ignited and weighed: as the weight was still 29·1 milligrams out of original 36·8, or nearly 80 per cent., notwithstanding a long series of erations intended to be only qualitative in general character, it was bbable that it represented the whole in its characters.

(*e.*) In a second examination, 25·5 milligrams of the powdered neral were first fused with a mixture of sodium and potassium bonates: after treatment with water and hydrochloric acid there was dently a considerable residue, from which, as already stated, the wnish tinge had disappeared: the weight of the residue was 23·6 lligrams: the solution was yellow, and yielded with ammonia a cipitate which consisted of sesquioxide of iron and weighed 1·2 lligrams: hence it is inferred that the iron is only present in the louring matter. The 23·6 milligrams of insoluble residue were fused h potassium bisulphate, and after removal of a trace of platinum the ution was oxidised and precipitated with ammonia. The whole of this cipitate was found to be dissolved by oxalic acid giving a limpid solution, as again excluding the rarer earths: the solution gave a bulky precipie with ammonia, which after ignition was found to weigh 23 milligrams, actically the original weight of the insoluble residue.

It is thus clear, as suggested by the results of the first examination, that whole is brought down by ammonia, and that the substance is either "earth" or some compound which is reprecipitated whenever its acid

solution is neutralised : on the other hand, if the substance is an earth i characters are incompatible with those of the known members of th group (iron-indium) to which the complete solubility of the ammon precipitate in oxalic acid and the complete precipitation of the hydr chloric acid solution by barium carbonate in the cold seemed to hav relegated it.

(*f*.) The above mentioned ammonia precipitate, when powdered an ignited, was yellow while hot, and white when cold : ignited in a curre of hydrogen, passed through the perforated lid of the crucible, the powde became dark grey in colour, but even after prolonged action the weigh was only reduced by a fraction of a milligram, and nothing appreciabl was extracted by means of dilute hydrochloric acid : when ignited in ai the powder resumed its original character.

The ignited precipitate is quite unacted upon by hot strong hydr chloric acid, even when the digestion is long continued.

It behaves in the borax and microcosmic beads in the same way as th original powder.

(*g*.) The above precipitate was again brought into solution in th same way as before, reprecipitated by ammonia, and the whole redissolv in hydrochloric acid. With this solution sodium carbonate gave a pr cipitate which redissolved when the reagent was in considerable excess the solution was partially precipitated on boiling, and the precipitate d not effervesce on solution in acid : it was found that the incompletene of the precipitation on boiling was not due to the presence of two kin of material.

Experimenting on a much smaller scale, the same reaction was observ in the case of ammonium carbonate.

This behaviour is so characteristic of zirconia that comparative exper ments were made on about the same weight of that material, and it w found that with this quantity of zirconia the solution of the ammonia pr cipitate in oxalic acid and the precipitation by barium carbonate in t cold are both of them complete. All the above reactions are thus co sistent with the mineral being zirconia coloured by a small proportion an iron compound.

(*h*.) A drop of the hydrochloric acid solution of the ammonia pr cipitate allowed to evaporate spontaneously on a glass slide gives crystallised residue consisting of long needles, each branching into seve others near its extremity.

The whole of the precipitate was dissolved in hydrochloric acid a allowed to evaporate more slowly in a watch-glass : it crystallised co

letely as long flat colourless transparent crystals of uniform character; in arts of the watch-glass, however, a faint yellow tinge indicated that a ace of iron was present: the crystals had an oblique termination (about 0°), and showed strong double refraction, the direction of extinction ing parallel to their longer edges. They disappeared immediately when oistened with water. On exposure to the air, they suffered alteration nd lost their action on polarised light.

Direct comparison with the crystallised product (hydrated oxychloride of rconium) derived from zirconia by a similar series of operations multaneously performed showed that distinction between them was impossible: these products are shown at the Meeting.

(*i.*) The nitric acid solution of the ammonia precipitate gives no trace precipitate with molybdic solution, showing the absence of phosphoric id.

(*j.*) Mixed with powdered potassium bisulphate and fluor spar, a mall portion of the ammonia precipitate gave no green colouration to the me, showing the absence of boric acid.

(*k.*) There is not the faintest colouration when a strip of zinc is solved in, or when hydrogen peroxide is added to, the hydrochloric id solution of the ammonia precipitate: showing the absence of ngstic, molybdic, titanic and niobic acids.

(*l.*) Various other experiments were made with the ammonia precipite and its hydrochloric acid solution:—

(1.) The precipitate is insoluble in acetic acid.

(2.) The hydrochloric acid solution gives no absorption-bands when examined with the spectroscope.

(3.) On addition of ammonium sulphide, the ammonia precipitate becomes tinged with green (trace of iron).

(4.) The precipitation by ammonia is completely prevented by the addition of tartaric acid.

(5.) Addition of ammonium sulphide to the last solution gives, after a me, a small precipitate of greenish colour (trace of iron).

(6.) The hydrochloric acid solution gives immediately a white gelanous precipitate with sodium phosphate.

(7.) It gives an apple-green precipitate with potassium ferrocyanide race of iron).

(8.) It gives no visible reaction with potassium ferricyanide, sulphate, bichromate.

(9.) If nearly neutralized with ammonia, it gives an opalescence ith ammonium oxalate, and afterwards a not very bulky precipitate:

but on filtration nothing remains on the filter, and the opalescent filtrat becomes clear on standing.

(10.) On conversion into sulphate, and expulsion of the excess o sulphuric acid, the residue dissolves in water: on warming, the solutio gives a considerable white precipitate soluble in oxalic acid.

(11.) Notwithstanding the complete solubility of the ammonia precipi tate in oxalic acid, addition of a few drops of that reagent to a small quantit of the hydrochloric acid solution seemed to give a slight precipitate.

(12.) The hydrochloric acid solution turns turmeric paper brown.

(13.) A borax bead, if saturated with the ammonia precipitate and the heated for some time in a Bunsen flame to volatilise the excess of solvent is found to contain long prismatic crystals.

All these reactions are consistent with the substance being zirconia.

Artificial Crystals of Zirconia.

Baron Nordenskiöld[1] obtained excellent microscopic crystals of zirconi by heating ordinary zirconia and borax together in a porcelain-oven: the belong to the tetragonal system and are isomorphous with cassiterite zircon and rutile.

MM. Lévy and Bourgeois[2] obtained crystallisations of two kinds b heating zirconia and sodium carbonate together, and the two forms, thoug both optically uniaxal, are apparently incompatible with each other: on kind consists of rectangular crystalline aggregations, perhaps reall identical with that obtained by Baron Nordenskiöld, the other consists c hexagonal composite lamellæ: the specific gravity of the latter kind is a low as 4·9.

For this new mineral I beg to propose the name *Baddeleyite*, in honou of Mr. Joseph Baddeley, by whom the interesting dense minerals c Rakwana have been brought to the notice of the mineralogical world.

APPENDIX.

Since the results of the above investigation were sent to *Nature* (189 Vol. 46, p. 420) for publication, a description of a new mineral, *Brazilit* has appeared in the *Neues Jahrbuch für Mineralogie* (1892, Band 2, p 141), as part of a letter sent by Dr. Hussak from Brazil in the month c June: the mineral is found as an accessory constituent of an augitic roc

[1] *Pogg. Annalen der Physik*; 1861, Vol. 114, p. 625.
[2] *Bull. Soc. Min. de France*: 1882, Vol. 5, p. 136.

S. Paulo, to which Mr. Orville Derby has given the name of Jacupirangite, and had been regarded three years ago by Dr. Hussak (who had seen only a small amount of material for examination) as probably orthite, a mineral with which it agrees in its more obvious external characters: it is mentioned as orthite in Mr. Derby's description of the constituents of the rock. More recently Dr. Hussak, on isolating a score of "flawless crystals" from the decomposed rock, recognised the distinctness of the mineral from orthite, determined the geometrical and physical characters, and decided from a chemical examination that the material was a tantalo-niobate of probably some member of the yttrium-cerium group. On January 3, 1893, I received from Dr. Hussak a separate copy of his paper with a statement written on the margin that the mineral, which had been sent to Sweden for a quantitative analysis, has been determined by Professor Blomstrand to be "almost pure zirconia."

As regards crystalline form, the parametral elements obtained by myself for Baddeleyite agree, though only expected to be of an approximate character, in a very satisfactory way with those determined by Dr. Hussak for the Brazilian mineral: Dr. Hussak's values being

$$a : b : c = 0{\cdot}98594 : 1 : 0{\cdot}51091 ; \ \beta = 98°45\tfrac{1}{2}' :$$

the parametral element c having been thus taken as half that of the corresponding element of Baddeleyite. For the reasons already mentioned (p. 149), the fundamental angle $a\,m$ (44°) was only given to what seemed the nearest degree: it is interesting to remark that in my measurement-book, under date July 1892, it is noted that the best pair of images corresponded to an angle of 44°18′: Dr. Hussak's final result is 44°17½′.

Dr. Hussak's crystals are flawless and rich in forms.

The descriptions of the optical characters of the two minerals are practically identical. The only important deviation of external character is in the case of the specific gravity; that of Baddeleyite is 6·025, that of selected crystals of the Brazilian mineral is 5·006.

Now it seems almost impossible that the specific gravity of crystals of almost pure simple oxide, presenting otherwise identical characters, can vary to this extent, and the explanation of all the difficulty will probably be found to be that Dr. Hussak's specimens really belong to two distinct minerals; that while the crystalline form and optical characters were determined from the one (zirconia), the specific gravity and the composition were originally determined from the other (tantalo-niobate of yttrium). In fact, it was stated in my letter to *Nature* that the Baddeleyite is associated at Ceylon with such a chemical compound, and I may

add that this associated mineral was there designated without the use o the expected species-name, for the very reason that it was found to have specific gravity (4·9) far below the inferior limit (5·5) hitherto observe in the case of undoubted Yttrotantalite: it was intended later to ascer tain whether or not the lowness of the specific gravity was associate with a difference in the chemical composition: this has since been done b my colleague, Mr. G. T. Prior, with the result that the mineral is foun to be chemically identical with Fergusonite. Further, the zirconia an tantalo-niobate from Ceylon are very similar to each other in gener aspect, and might easily be mistaken the one for the other. It nee scarcely be pointed out that this explanation would be consistent with th complete accuracy of the observations of Dr. Hussak, whose reputatio stands so high in the annals of Mineralogical Science.

There remains the fact that two names have thus come to be suggeste for the same mineral: according to the Rules of Nomenclature formulate by Dana (Rule 13*d*) the name Baddeleyite should stand: I may re mark that the name Brazilite was in use in England, commercially a least, eight years ago for the specification of an oil-bearing rock found i the neighbourhood of Bahia.

Postscript.—In a letter just received by me from Brazil, Dr. Hussa with characteristic courtesy, offers to simplify mineralogical nomenclatu by withdrawing the name Brazilite. He further informs me that by a unlucky series of accidents the 5½ grams of carefully selected materia already recognised by Dr. Hussak from its geometrical and physic characters to be a new mineral, had been sent off by post to Profess Blomstrand, in Sweden, 18 months ago, but failed to reach its destinatio the letter of Professor Blomstrand to Brazil notifying the non-arrival the material likewise miscarried; though the next 1½ grams reach Sweden safely, the letter giving the analytical results did not get to Brazi meantime Dr. Hussak began a six months' journey into the interior the country.

OBITUARY.

Thomas Davies, F.G.S.

[Died 21st December, 1892.]

Mr. Thomas Davies was born on 29th December, 1837, in the eighbourhood of London, and was the son of Mr. William Davies, F.G.S., the Geological Department of the British Museum. His early education as of a very elementary character, and the period of his school-life was ief: finding town life irksome, and yearning for freedom and adventure, took to the sea at the age of 14, and during the next four years led a ving life, visiting China, India, and various parts of South America. e was then prevailed upon by his father to adopt a more settled mode of istence, and on the separation of the Department of Mineralogy from at of Geology, was appointed in 1858 a third class attendant at the itish Museum, under Professor Maskelyne, to whom the care of the inerals had been assigned: in the following year he added to his sponsibilities by marriage.

During the next nine years, save for a short interval when Dr. iktor von Lang was an assistant in the Department, Mr. Davies was the le helper of Mr. Maskelyne in the arrangement and examination of the ineral collections: during this time Mr. Maskelyne effected a thorough ange in the classification and arrangement of the minerals, and labelled th localities the large number of specimens that were without any scriptions except what could be traced out in old catalogues. In this rk and in cleaning and arranging some tons of specimens, of which any were entirely valueless, the patient and intelligent aid of 'young avies' alone rendered it possible to carry out the preliminary operations. s the collection grew into orderly arrangement, the registration and belling of specimens were entrusted to him by Mr. Maskelyne. It was us that he gradually acquired an eye-knowledge of minerals, which has rely, if ever, been surpassed. His perception of the peculiarities of a ecimen was remarkably quick, while his remembrance of individual ecimens was almost marvellous. One instance of his powers of emory may be mentioned as an illustration:—

On his return to the Museum in 1891, after twelve months' absence

on sick-leave, it was a matter of some anxiety to his friends as to whether his memory of specimens might not have been permanently affected by his long illness: this anxiety was soon set at rest, for glancing at some specimens which had been acquired during his absence, and noticing one acompanied by a written statement of its locality, he made the immediate remark that the matrix was identical with that of a specimen already in the collection, of which the locality was unknown, and expressed his delight at being at last able to put a locality-label with it. In this case the specimen could not have been seen by him for at least 12 months, and possibly had not attracted his attention for years: and to the ordinary mind there seemed nothing remarkable about the specimen to fix it in the memory.

In fact, it was particularly in the habits, the localities, the associations and modes of occurrence of mineral species that he concentrated his interest: and to his knowledge in this direction his earlier training, under the eye of Mr. Maskelyne, in the labelling of the minerals accumulated in the cases and drawers very largely contributed.

In the early years of Mr. Davies's Museum life, Mr. Maskelyne was further engaged in the study of thin sections of meteorites, and initiated Mr. Davies into a knowledge of the microscopic characters of rock-forming minerals, a mode of investigation then almost unknown: in this direction his quickness of perception and excellence of memory had full scope for play, and Mr. Davies soon became extremely skilful in the microscopic determination of minerals in rock-sections, and in the recognition of peculiarities of rock-structure. Few practical petrologists approached him in this faculty.

Nor did he neglect to improve his general education: with this end in view he attended the evening classes at the Working Men's College in Great Ormond St., and in the course of time acquired a knowledge of both French and German: he was also familiar with plants and fossils, a knowledge derived from his father.

His remarkable qualifications attracted the early attention of Mr. Maskelyne, and in 1862 were officially recognised in his promotion by the Trustees from the grade of attendant to that of Transcriber or Junior Assistant. In 1880 he was promoted to the grade of First Class Assistant: by a remarkable coincidence, his father, Mr. William Davies, who had long been renowned for his large practical knowledge of important branches of palæontology, and especially of fossil fishes, and had likewise begun Museum life as an attendant, obtained the same promotion on the same day. In the same year he was awarded the Balance of the Proceeds of the

Wollaston Fund by the Council of the Geological Society "as a testimony of the value of his researches in Mineralogy and Lithology." At the time of presentation, the President, Dr. Sorby, said:—"Valuable as have been the results which you have made public, we all feel that in many cases you have still further advanced our science by the generous assistance which you have afforded to others." Still later, in 1889, the name of davieside was given to a new mineral, "in honour of Mr. Thomas Davies, who has now been associated during upwards of thirty years with the British Museum Mineral Collection, and whose mineralogical experience and Werthauptian eye have ever been willingly placed at the service, not only of his colleagues, but of every one who has been brought into relationship with him."

He became a Fellow of the Geological Society in 1870, and was an early Member of the Mineralogical Society of France.

His published work was not voluminous: it relates almost exclusively to the microscopic characters of the Pre-Cambrian Rocks. He contributed, however, the bulk of the articles on Mineralogy and Petrology for Cassell's "Encyclopædic Dictionary," and for some years edited the Mineralogical Magazine for this Society. The following is a list of his publications:—

1. The researches (of Mr. David Forbes) in British Mineralogy. *Geol. Mag.* 1867, Vol. 4, p. 575: 1868, Vol. 5, p. 102.
2. Notes on Vauquelinite from Scotland and Cantonite from Cornwall. *Min. Mag.*, 1877, Vol. 4, p. 112.
3. Note on a rock specimen from the centre of the so-called porphyritic mass to the East of Taly-y-sarn. *Quart. Jour. Geol. Soc.*, 1878, Vol. 34, p. 152.
4. Note on Jadeite and Jade. *Geol. Mag.*, 1878, Vol. 5, p. 192.
5. Appendix on the microscopic structure of some Dimetian and Pebidian rocks of Pembrokeshire. *Quart. Jour. Geol. Soc.*, 1878, Vol. 34, p. 161.
6. Appendix on the microscopic structure of a new group of Pre-Cambrian rocks (the Arvonian) in Pembrokeshire. *Ibid.*, 1879, Vol. 35, p. 285.
7. Preliminary Note on old Rhyolites from Bouley Bay, Jersey. *Min. Mag.* 1880, Vol. 3, p. 118.
8. Petrological notes on the Pre-Cambrian rocks of West and Central Ross-shire. *Geol. Mag.*, 1880, Vol. 7, pp. 103, 155, 222, 226.
9. Appendix on the microscopic structure of the Pre-Cambrian rocks of Pembrokeshire, with especial reference to the St. David's District. *Quart. Jour. Geol. Soc.*, 1880, Vol. 40, p. 507.

Mr. Maskelyne, for whom he was right-hand man and almost sole working helper during upwards of twenty years, looks back with fond regret on the uninterrupted happiness of their association. According to my own experience during the last fifteen years he was a most excellent colleague, always cheerful, good tempered, and kind-hearted, ever ready to help in any direction, however much it might interfere with the particular work he had immediately in hand, ever willing to learn, for any question.

that other side of which the possible existence might not have suggested itself to him. At home he was an enthusiastic gardener: wet or fine, absolutely reckless of weather, he was at work from early sunrise, and could boast the possession of one of the best managed gardens in the neighbourhood. His love of fresh air and the bustling east wind never left him: even after recovery from the long illness which two years ago had taken him to the verge of the grave, and from which he never fully recovered, he did not hesitate to show his former contempt for the protection of an umbrella, and notwithstanding the remonstrances of his friends might occasionally be seen still enjoying the beating of the wind and rain on his unprotected face.

Mr. Davies leaves a widow and a family of five daughters and four sons to mourn his loss.

He was an Original Member of the Mineralogical Society, and Foreign Secretary for several years preceding his death.

A "Thomas Davies Memorial Fund" has been initiated by the Council, with Mr. Maskelyne as Chairman of the Executive Committee: Dr. Hugo Müller, F.R.S., 13 Park Square East, Regent's Park, N.W., as Treasurer, will be glad to receive contributions from any who wish to avail themselves of this opportunity of commemorating the services of Mr. Davies to Mineralogical Science.

L. Fletcher.

REVIEWS.

Georgio Spezia, *Professor in the University of Turin. "Sull' Origine del Solfo nei Giacamenti Solfiferi della Sicilia." Torino, G. Candeletti, 1892, 8°, pp. 130, 2 phototype plates.*

The origin of the sulphur so abundantly found in Sicily along one geological horizon, extending over a great area, has been the source of much discussion. Prof. Spezia has, in the book before us, made a very careful and critical study of the subject in all its bearings. We have first a description of the minerals that accompany sulphur, such as celestine, calcite, aragonite and the different forms of silica, together with that curious one known as melanophlogite. He shows that these minerals are superposed on each other in no special order, and therefore may be considered as in general contemporaneous, and that certainly they were deposited through the agency of water—at any rate so far as calcite and silica are concerned.

The author carefully studied these materials in the mines and likewise some springs met with in mining operations, the water of which was found to contain and to deposit minute crystals of calcite, sulphur, celestine and silica. The paragenesis, alteration and relation of the fissure and drusy deposits and their mineral species are discussed.

The origin of such an enormous quantity of strontium sulphate is the key-note of the author's arguments, for he very justly shows that its relative proportion to the gypsum beds is enormously different to what would be the case in ordinary sea-water. Silica to a certain extent offers a similar difficulty.

Another question that the author discusses is the intimate relation of the Tripoli beds with the sulphur deposits. Reference is made to diatomaceous deposits in all parts of the world, which in most cases are associated with volcanic action. The author suggests, therefore, that the soluble silica derived from hot springs only could afford the large amount of silica for the growth of the diatoms in such large proportions. The origin of the bitumen of the sulphur-bearing series is discussed, and the author favours the idea of the development of hydrocarbons by igneous action, independently of the remains of organic matter in the subjacent rocks. In this chapter several slips are made such, for instance, as the

statement that the occurrence of graphite and carbonic acid cavities a inclusions in the rocks and minerals of granites, porphyries and basalt prove the chemical origin of the bitumen hydrocarbons. These inclusion simply prove the penetration of carbonaceous strata by the eruptive rock that contain them. The opinions of all those who have suggested a explanation of the origin of the sulphur deposits are given, and they ar combatted one by one.

Finally the author gives his own conclusions. He considers that thes different minerals are derived in part from thermal springs and in pa from sea water of a salt lake only communicating by a very narrow inl with the main ocean. The gypsum is deposited when the water reache a certain point of concentration, but the salt cannot crystallise as it drai out by the canal, being replaced by dilute sea-water on the surface.

If Prof. Spezia has not proved his case he has made a very able plea ing, and has done as much as a mineralogist is called upon to do. Th final decision of the question must be left in the hands of the fie geologist, who has in this valuable memoir a guide to the sort of evidenc required to settle this knotty question.

Borneo: Its Geology and Mineral Resources. By Dr. Theodo Pozewitz; translated from the German by Dr. F. Hatch. Edwar Stanford, London, 1892.

This work consists of nearly 500 pages. It has a good table of co tents, but no index, and is divided into four chapters. Of these the fir is "Historical" and is really of little use to the general reader. Th second is "Geological"; the third, an account of the "Useful Minerals" and the fourth on "Mining Operations."

There is throughout the whole work a tendency to treat the subje historically, involving a great amount of needless repetition; while far t many paragraphs are devoted to the statement that there is no accura information upon some point or other. The book, however, contai much valuable information for those who will take the trouble to sift out.

The principal points brought out in "Geological" chapter are brie as follows: —

The whole scenery and structure of the island is dominated by a va number of massive intrusions of granite, diorite, gabbro, etc., who greater length usually lies north-east and south-west. This is the dom nant strike of nearly all the other rocks in the island.

These igneous massifs are scattered all over the interior of the country; large mass of the igneous material forming the great flat-topped moun- in of Tebang in the centre of the island.

Near the north end of Borneo one of these igneous masses, inabalu, attains an elevation of 13,698 feet. As a rule, they are sur- unded by schists, and the "Old-slate-formation," the latter probably Devonian age.

There is no clear statement from the author as to the relation of these ree rocks to one another, but from other explorers' notes (quoted by m) it appears that the igneous "massifs" are intruded into the schists d slate. The schists are claimed as older than the slate, and, in fact, cnæan, but without any evidence. The whole of these rocks hang gether and form the greater part of the high ground or "Mountain rmation." They are much traversed by quartz-veins, which contain riferous pyrites, gold and other minerals. Their decomposition is the urce of the minerals to be met with in the superficial formations.

The *Carboniferous Series* is represented by conglomerates, sandstone, d limestone. Fossils have placed the age of the limestone beyond doubt.

Cretaceous.—A small patch of cretaceous rocks is shown in the south- st part of the island, and fossils have been collected proving the exis- ce of such rocks in other places.

Tertiary, or Hill Formation.—The elevated areas or Mountain Forma- n are more or less completely surrounded by a fringe of low-lying hill d composed of Tertiary strata.

These are divided into two groups. (1). Older Tertiary, or Eocene; New Tertiary, the exact age of which seems very uncertain; but e latter rests unconformably on the former.

Eocene.—A group consisting of sandstones, shales and coals in the best own area, in the south-east of the island, attains a thickness of about 0 ft., and contains 19 coal seams (given in a detailed section), but y two are thick enough to have much practical value. The coal is ck and lustrous. The want of proper means of transport has largely ited its working. But in truth the fatal objection to the entire coal d of Borneo is the extremely disturbed state of the strata. Dips of 30 grees are very common. With such dips as occur here the coal must ined like a vein, a very expensive proceeding.

Both the groups of Tertiary rocks are much penetrated by igneous usions in which the dominant types belong to the andesite group,

There seems no doubt that these are more recent than the granites c diorites, &c., but there really is no clear evidence as to the date of th latter.

That portion of the book which deals with the useful minerals contains considerable amount of information about the occurrence and working gold, diamonds, platinum, antimony, mercury, petroleum, &c., but here, a elsewhere, the book is largely a compilation. An observer possessed greater scientific knowledge and experience could doubtless have con tributed more original observations on the geological and mineralogica nature of the island during a three years' residence in the country; bu still the fact remains that the book is a convenient summary of th voluminous Dutch literature, and is practically the only available Englis treatise on the subject.

Minéralogie de la France et des Colonies. By A. Lacroix. Baudry Cie, Paris, 1893. Tome I. (1re Partie), 304 pages.

M. Lacroix, whose numerous researches upon minerals and rock especially as regards their optical characters, are well known to all stu dents of mineralogy, has in this book supplied a long felt want. Top graphical mineralogies exist for most European countries; we need on instance the Lexicon of Zepharovich for Austria, of Toth for Hungary, Wenzel for Saxony, the Materialen of Kokscharow for Russia, and th books of Greg and Lettsom for the British Isles, and of Kenngott f Sweden, but up to the present time there has been no such book reference for France. The present volume is the first instalment of work which bids fair to surpass any of the preceding for completene of detail.

The part first published begins with the silicates, which, together wi the titanates, are to constitute the first volume; this order being adopt because the author has many new facts to communicate with regard these minerals; we may also expect that the first volume will be bo the most interesting and the most prominent part of the work, conside ing the important development of crystalline schists and volcanic rocks France and the comparative paucity of vein minerals and ore deposits.

The book is well illustrated; not only are the associations and mod of occurrence explained, special regard being paid to the geologi nature of the associations, but the characters of the minerals are fu described; the physical data are given in the admirable form with whi we have been familiarised by the book on the Minerals of Rocks writt

by the same author in conjunction with M. Michel-Lévy; and a large amount of the optical and other information is new.

The author does not hesitate to cross the frontier into Spain, Germany, Belgium, or the Alps, where the formations which he is describing are continued across the border.

We have no doubt that M. Lacroix will produce a work which must long remain our standard authority on French minerals.

Abstracts.

On the Fayalite of the Volcanic Enclosures of the Trachytes of Capucin (Mont-Dore). By M. A. Lacroix (*Bull. Soc. Fr. Min.* Vol. XI p. 10).

In the trachytes of Mont-Dore, and especially in those of the Capuc there occur numerous enclosures of other rocks. These enclosures divisible into two groups, the one comprising old quartziferous ro (cordierite-gneiss, and more rarely granites and fragments of quart The other group comprises volcanic rocks, some of which occur in pla in the neighbourhood, either as lava-flows (augitic trachytes with ho blende, &c.), or as veins (hornblende-andesites), while, on the other ha there are enclosures of rocks (andesites of special character passing i ophitic and granitoid types—diorites, diabases, &c.), which have not been met with in place.

In the enclosures of each of these groups drusy cavities are of comm occurrence. In the one group of enclosures hypersthene, tridym orthoclase and magnetite have been noted, while in the other volca series of enclosures monoclinic pyroxene and rose-coloured zircon h been found.

In examining a number of these enclosures the author has, in specimen, detected the presence of fayalite occurring under much same conditions as in the Yellowstone Park and in the Lipari Isles.

The rock containing the druse in which the fayalite occurs i hornblende-andesite passing into diabase. The cavities in this enclos are lined with various minerals such as yellowish-green hypersthene clear rose-coloured zircon, resting upon a coating of orthoclase tridymite.

One of the cavities measuring about 4 cm. by 2 cm. exhibits diffe minerals, viz. magnetite, biotite, fayalite and greenish-yellow hy sthene.

These minerals are attached to a layer of secondary orthoclase tridymite, covering fragments of corroded felspar of earlier origin.

The author, after describing the characters presented by the magne and biotite, states that the fayalite occurs in crystals measuring ba 0·4 mm. When transparent, which is seldom, they are of a golden ye colour. They are often opaque.

Goniometric measurements were impossible, since the larger crystals re in all cases covered by a rough incrustation of hæmatite, while the ansparent ones were too small for measurement. Owing to the flatten- g of the crystals in the plane (001) it was, however, possible to mea- re the plane angles of the prismatic zone under the microscope with fficient accuracy to determine the faces (010) (100) and (210), together th some exceedingly small faces which are probably (011), (021) and 11).

Two types were observed which differed in the relative development of e faces (210) and (100).

The most simple forms consist of small lamellæ (001), (010), (210), ngated in the direction of the edge of the zone 001/010.

When the face (100) is present it either slightly truncates the acute gle 210: $2\bar{1}0$ or it *notches it* extensively, the face 210 being then atly reduced. In this case the crystals have the appearance of tetrago- l plates.

The colour is golden-yellow (with very feeble pleochroism) in crystals of mm. thickness; the very thin crystals are colourless. The colour pears to be due to a ferruginous pigment which, at times, forms a kind reddish film within the crystal, but which is more usually localised as ll filiform inclusions parallel to a difficult cleavage in the direction 0).

The plane of the optic axes is parallel to (100). The obtuse bisectrix s perpendicular to (001) and the optic axial angle is very wide.

These properties, taken in conjunction with an easy solubility in acids in gelatinisation), and the large amount of iron carried into solution, fice to identify the mineral as a species of the olivine group, and more pecially as fayalite.

After comparing the fayalite of the Capucin with that described by dings from the Yellowstone Park, to which the rectangular forms of the mer bear a close resemblance, the author points out the close relation the Capucin crystals with those of Monte della Guardia (Lipari), also scribed by Iddings, and adds that the fayalite of the Capucin and the nerals which accompany it have certainly been produced in the wet y at a high temperature. The enclosures at the moment of their velopment by the trachyte must, he considers, have been impregnated fluids charged with mineral matter which then deposited the latter in form of crystals. The chemical composition of these fluids must have en modified by the enclosure itself, since the minerals formed vary cording to the nature of the enclosure in which they occur. The author

adds, "It is interesting to see minerals, such as tridymite, orthocla and fayalite associated, minerals of which the acidity is very differen This, it is true, is less surprising at Mont-Dore than it would be in oth localities, since certain trachytes of this region contain olivine as essential constituent."

The orthoclase of this locality is generally flattened parallel to (001), in the crystals from the Yellowstone Park described by Iddings. F. R.

Bone Turquoise.—"Occidental turquoise," or turquoise of the *nouve roche*, is generally admitted to be a substance of organic origin, as ind cated by its names *bone-turquoise* and *odontolite*. In order to determi its precise composition M. Ed. Jannettaz has analysed specimens plac at his disposal by M. Mellerio (*Bull. Soc. Franc. de Min.*, 1890, XI p. 106). Details of the method of analysis are given. The auth deduces from his results the following composition: $CaCO_3$, 10·7 $Ca_3P_2O_8$, 72; $Fe_3P_2O_8 + 8H_2O$, 16·82 = 99·52. Neither fluorine n copper could be detected. The specimens analysed had a spec. grav. 3·09, but others reached 3·25. Thin sections examined between cross nicols show a cloudy amorphous base, in which are embedded thin paral fibres which extinguish at about 30° to their long axis, and resemb fibrous crystals of vivianite. The turquoise displays no organic stru ture, except certain canaliculi now occupied by iron phosphate, similar those seen in sections of dentine from recent animals, but there, of cour uncoloured. M. Jannettaz concludes that the occidental turquoise is organic origin, but has been so altered as to be now fairly classed wi substances truly mineral, and that it owes its fine colour to the presen of secondary vivianite. F. W. R.

Natural Soda.—The growing demand for sodium carbonate giv great importance to the sources of "natural soda" afforded by t alkaline lakes and dry deposits scattered over the arid region of t "Great Basin," between the rocky mountains and the Sierra Neva Mr. T. M. Chatard has studied the subject as a chemist, geologist a technologist (*Bulletin No. 60, U.S. Geological Survey*, dated 1887-188 Natural Soda is the residue left on the spontaneous evaporation alkaline waters. According to the author it is, when pure, a defin compound of one molecule of sodium monocarbonate and one of bicarbonate. This compound occurs native as *urao* (Na_2CO_3. $NaHCO_3$ $2H_2O$). To every molecule of Na_2O there are four thirds of a molecule CO_2: hence he terms this a *tetra-trita*—or for shortness sake a *tetrita*

carbonate. Mr. Chatard's researches throw doubt on the existence of a so-called sesquicarbonate, such as is supposed to occur in trona; and he concludes that there are but three sodium carbonates, viz. the monocarbonate, tetritacarbonate and the bicarbonate. In natural soda the urao is usually associated with other sodium salts, especially the sulphate and the chloride. The origin of the soda is referred partly to the direct decomposition of rocks through the agency of air and water, and partly to decompositions occurring in soils and in closed basins. A dry climate is the principal factor in the accumulation of deposits of natural soda. Mr. Chatard describes the occurrence of deposits of soda in Hungary, Egypt, Armenia, Venezuela and the Great Basin of the West. F. W. R.

Elæolite-Syenites, etc., in Arkansas.—The latest *Report of the Geological Survey of Arkansas* (for 1890, Vol. II.) is devoted to a full account of the peculiar igneous rocks of that State by the late J. F. Williams. These all belong to the elæolite-syenites and allied types with their associated dyke-rocks, and the intrusions are referred to about the close of the cretaceous period. The chief centres are four in number, viz. Fourche Mountain, Saline County, Magnet Cove, and Potash Sulphur Springs, while numerous basic dykes of clearly cognate origin are more widely distributed.

The elæolite-syenite is of rather acid composition (I), and contains 'microcline-microperthite,' elæolite, and biotite, with diopside but not hornblende. The elæolite-syenite dyke-rocks are of several types, including miarolitic elæolite-syenite, miarolitic quartz-syenite (with 64·63 p. c. of silica), pegmatitic elæolite-eudialyte-syenite (closely resembling some Norwegian rocks described by Brögger), and other interesting types. One of these, named 'pulaskite,' comes near Brögger's Laurvik rock, with its 'crypto-perthite' felspar, but has hornblende as the dominant bisilicate mineral, and shows a tendency to a porphyritic structure (Analysis II.) Another rock contains cancrinite and occasionally sodalite in addition to the elæolite and felspar (III). More markedly porphyritic types are a rock with porphyritic elæolite, an 'elæolite tinguaite' with porphyritic orthoclase, and an 'ægirine-tinguaite,' without elæolite.

A very interesting feature is the occurrence of leucite-rocks corresponding to some of the elæolite-bearing types. The leucite-crystals, however, while preserving their form, are always replaced by a mixture of orthoclase and elæolite.

The basic dykes show a considerable range of varieties. Some corres-

pond to the monchiquite type, recently described by Rosenbusch and Hunter as associated with the elæolite-syenites of Brazil and Portugal. For others the names 'fourchite' and 'ouachitite' are proposed, the latter by J. F. Kemp, who has examined a large number of the dykes. They differ from monchiquite in the absence of olivine. The fourchites are characterised by augite, sometimes with hornblende also: the ouachitites are rich in black mica. Analyses of some of the rocks are quoted below.

The author describes the contact-phenomena in the rocks contiguous to the intrusions. Some of the metamorphic effects are remarkable, and, in particular, the numerous special minerals which have made Magnet Cove a famous locality occur in this connection. The literature of this subject is reviewed and original observations added, the chief species noticed being arkansite (brookite), rutile, perofskite, vesuvianite, and monticellite.

	I	II	III	IV	V	VI
SiO_2	59·70	60·03	53·38	43·50	42·03	36·40
TiO_2	—	—	—	2·10	3·70	0·42
Al_2O_3	18·85	20·76	20·22	18·06	13·60	12·48
Fe_2O_3	4·85	4·01	1·56	7·52	7·55	8·27
FeO	—	0·75	1·99	7·64	6·65	4.59
MnO	—	trace	trace	—	trace	—
MgO	0·68	0·80	0·29	3·47	6·41	11·44
CaO	1·34	2·62	3·29	13·39	14·15	14·46
Na_2O	6·29	5·96	7·89	2·00	1·83	0·97
K_2O	5·97	5·48	6·21	1·30	0·97	3·01
H_2O (ign)	1·88	0·59	3·43	1·22	1·08	2·36
P_2O_5	—	0·07	—	—	0·57	1·04
SO_3	—	—	—	—	0·08	CO_2 3·94
NaCl	—	—	—	—	05·6	—
FeS_2	—	—	1·77	—	0.05	—
	99·56	101·07	100·03	100·20	99·23	99·38

I. Elæolite-syenite, Fourche Mt.; anal. W. A. Noyes: sp. gr. 2·557.

II. Pulaskite, Fourche Mt.; anal. R. N. Brackett and J. P. Smith: sp. gr. 2·635.

III. Elæolite-cancrinite-syenite dyke-rock, Diamond Jo; anal. ditto.

IV. Amphibole-morchiquite, Magnet Cove; anal. W. A. Noyes: sp. gr. 3·051.

V. Fourchite, Fourche Mt.; anal. W. A Noyes and R. N. Brackett.

VI. Ouachitite, Arkansas; anal. L. G. Eakins. A. H.

Grünerite in Michigan.—A peculiar amphibole associated with some of the iron-ores of Lake Superior has been called both actinolite and anthophyllite. A. C. Lane and F. F Sharpless (*Amer. Jour. Sci.* XLII. 15; 1891) have recently shown that it does not belong to either, being distinctly monoclinic, while it is entirely wanting in lime. It is indeed a monoclinic, non-aluminous, ferro-magnesian amphibole, and is thus referred to grünerite. In the specimen from Champion Mine analysed by the authors the magnesia is nearly double of the ferrous oxide, unlike typical grünerite, but apparently the ratio Mg : Fe varies in different samples from Michigan. The mineral occurs in small fibres having a silky lustre due to the high refractive index (1·7). The birefringence is not high, being above ·030. The colour and pleochroism are also faint; the maximum extinction-angle (c to γ) is between 15° and 20°; the optic axes include an angle of between 50° and 80°. Repeated twinning parallel (100) is common. The specific gravity is about 3·2 to 3·3. The authors suggest that the apparently rhombic anthophyllites may be the result of 'submicroscopic' [meaning ultramicroscopic] twinning in a monoclinic amphibole of this type.

Lane also describes an occurrence of amphibole allied to riebeckite as a secondary fibrous growth on the primary hornblende of a syenite, closely analogous to those described by Whitman Cross [*Min. Mag.* IX. 1, Abs.]. The extinction angle is about 75°, forward. The pleochroism is α, blue to greenish blue; β, violet or reddish blue; γ, yellow. The birefringence is weak. A. H.

The irruptive rocks of the Black Forest.—An interesting paper on the igneous rocks near Durbach in the northern part of the Black Forest is contributed by A. Sauer (*Mitth. d. grossh. badischen geol. Landes-*, Vol. II. p. 233). The leading rock-type in that neighbourhood is described as a normal 'granitite' or biotite-granite consisting essentially of quartz, felspar, and biotite. The large orthoclase crystals which give the rock a porphyritic aspect are found to be not of a simple kind. The original orthoclase contains also patches of orthoclase and microcline, besides definite inclusions of plagioclase and more rarely biotite. The twinning of the albite and the cross-twinning of the microcline may be in part due to the dynamic changes, but this is not always the case, for microcline occurs in druses. The analysis of the microcline (column I.) indicates the percentages :—of potash-felspar 74, soda-felspar 24, and lime-felspar 2. The plagioclase of the rock has a zonal structure, the margin of a

crystal being more acid than the interior: the average is a basic oligo clase.

	I.	II.	III.	IV.
SiO_2 ...	64·53	67·70	51·05	54·89
TiO_2+ZrO_2 ...	—	0·50	1·76	—
Al_2O_3 ...	19·14	16·08	14·49	1·50
Fe_2O_3 ...	tr }	5·26	4·16	5·06
FeO ...	— }		4·37	7·46
MgO ...	—	0·95	8·16	16·01
CaO ...	0·44	1·65	5·11	12·08
Na_2O ...	2·89	3·22	1·85	0·37
K_2O ...	12·40	5·78	7·24	0·38
P_2O_5 ...	—	—	0·70	—
Ignition ...	0·34	—	1·05	2·72 (H_2
	99·74	101·14	99·94	100·47

The bulk-analysis of the rock gives the figures in column II. showi that it belongs to the less acid members of the family. Dark patches more basic composition occur plentifully in some parts of the mass, a some of them contain hornblende and augite, as well as biotite.

A local modification of the rock at the margin of the mass contai pseudomorphs of pinite after cordierite. A more striking margi modification is a mica-syenite which the author characterises as a spec type under the name Durbachite. The peculiar chemical composition (II of this rock links it with the lamprophyres. Mineralogically, it consi of biotite and orthoclase with accessory hornblende, plagioclase, etc., a very little quartz. The orthoclase occurs in porphyritic crystals, a also in little grains as part of the groundmass. The latter have often parallel arrangement, and the space between them consists essentially a mass of biotite-flakes. In sections parallel to (010) the orthocl gives extinction-angles varying from 5° to 10°, apparently owing to diff ent proportions of soda-felspar in isomorphous mixture with the pota felspar. The variations follow a zonal arrangement; but sometimes interior, sometimes the exterior of the crystal gives the wider angle. T biotite has normal characters and does not (like that of the biotite-grani contain lithia. The hornblende is light green in section, and or cleavage-flake gives an extinction-angle of 14°. A careful chemi analysis yields the figures in column IV. (sp. gr. 2·94 to 2·96). The o gen-ratio between silica and total bases is closely 1 : 1, and the aut

nows that the cons itution of this hornblende must be expressed as an somorphous mixture of the silicates $MgSiO_3$, $CaSiO_3$, H_2SiO_3, Fe_2SiO_5, ne ferrous oxide, alkalies, and alumina being included with the magnesia, ater, and ferric oxide, respectively. A. H.

A palæozoic Leucite-rock from Siberia.—K. von Chrustchoff adds another ocality to the list of leucite-rocks, and one of peculiar interest. The rock xamined was collected on the right bank of Tunguska, where it forms a flow early overlain by limestones with *Favosites*, *Halysites*, *Cyathophyllum*, c. (*Neues Jahrb. für Min.* 1891, Vol. II. p. 224). It is an aphanitic ock, in which, however, the little white crystals of leucite, up to 1 mm. in iameter, are visible. A microscopic study shows zircon, apatite, iron-ores, ucite, nepheline, augite, anorthoclase, sanidine, and residual glass. he more important extra-European records of leucite-bearing rocks are ow: Java (Vogelsang, 1876), Wyoming (Zirkel, 1875), Cape Verde oelter, 1882), Lower California (Chrustchoff, 1884), New South Wales dgeworth David, 1887), Brazil (Derby, 1887), Kilimanjaro (Hyland, 88), Asia Minor (Lacroix, 1890), and Siberia (Chrustchoff, 1891).

A. H.

On Monchiquite, a Camptonitic volcanic equivalent of Elæolite-syenite. . Hunter and H. Rosenbusch (*Min. Mitth.* XI. 1890, pp. 445-66) llow up in the case of the Camptonites and elæolite-syenites the work f tracing out the relations of the plutonic and corresponding volcanic ocks. The series of rocks which they describe were collected by O. A. erby in Brazil. The elæolite-syenites of Brazil are always found accom-anied by veins and dykes of rocks having a basaltic to lamprophyric ructure, and showing a close connection in chemical and mineral com-osition to the tephrites, camptonites, theralites and similar rocks. efore Derby discovered these rocks in Brazil, similar rocks had been nown in S. Portugal, and called monchiquites. The specimens described y the authors were from small veins in the gneiss opposite Cabo Frio, nd from the Serra de Tingua and Santa Cruz railway. Derby's field ork showed the intimate association of these rocks with the elæolite yenites.

The monchiquites are greyish black compact rocks, showing to the aked eye porphyritic constituents of amphibole, pyroxene, mica and ivine or its decomposition products. The relative amounts of these con-ituents vary considerably for different localities. In the Cabo Frio pecimens mica predominates, and the rocks resemble minettes: in those

from the Santa Cruz railway amphibole in long needles takes the place of the mica, and the rocks are vogesitic to camptonitic; in other cases from lack of mica and amphibole they become very like basalts. The ground-mass however, is in all cases the same whatever may be the variations of the porphyritic constituents in nature or amount. It consists of a colourless isotropic glass containing microscopic crystals of the porphyritic constituents. The specific gravity of these rocks varies from 2·723 to 3·017. Of the constituents the iron ores, apatite and olivine are intratelluric, the pyroxene and amphibole have two periods of consolidation.

In the rock from Santa Cruz railway occur minute crystals of a hornblende, which on account of its optical properties is referred to Riebeckite. Chemical analyses show the close relation between the monchiquites and the elæolite-syenites. The analysis of the glassy base showed an almost perfect correspondence with the composition of an eleæolite-syenite. Intergrowths of augite and hornblende are common. The hornblende is generally a peculiarly basic kind ($SiO_2 = 35·76$) which in its low percentage of monoxide and high contents of alkalies and sesquioxides approached the Barkevig variety of Brögger. The augite is mostly reddish violet in colour like the titaniferous variety of nepheline rocks; but a green variety also occurs in small amount, usually as the innermost zone of a zoned crystal. Analysis showed that the violet augite was very similar in composition to the augite of the Kaiserstuhl limburgite. Comparison of the bulk analyses proved the close analogy between the monchiquites and the camptonitic rocks from New Hampshire and Montreal, as well as the so-called picrite-porphyry of Aninaschacht in Hungary. G. T. P.

On the so-called augite-porphyry from Ehrwald—A. Cathrein (*Verh. d. k. k. geol. Reichsanst.* 1890, pp. 1-8) determines the true character of the Ehrwald rock which had been by Pichler ascribed to the augite porphyries and by Rosenbusch doubtfully to the Teschenites. The porphyritic augites standing out prominently in a greyish green groundmass give the rock the appearance of an augite-porphyry, but the white patches which were supposed to be felspar consist of zeolites or carbonates. Under the microscope the structure is basaltic but no felspar is visible. The porphyritic constituents are augite and rhombic pyroxenes. The augite is idiomorphic with zonal structure, weak pleochroism and large extinction angle. The rhombic pyroxene, from its colour and pleochroism ascribed to hypersthene or bronzite, is mostly altered to bastite which occurs in long crystals showing a fibrous structure with extinction along the length of the fibres. A little enstatite is also found in almost colou

ess irregular fragments altering in the same way to bastite. Biotite occurs both as a porphyritic constituent and in the groundmass. Beside the mica the minerals of the groundmass are rhombic pyroxenes, augite, apatite, magnetite and hornblende. The latter mineral is of the brown basaltic type, and often occurs in parallel intergrowths along the vertical axis with augite. The augite shows the zonal and hour-glass structure, and here and there occurs in radial groups reminding one of the chondrules in meteorites.

The apatite is tolerably plentiful in needles penetrating and enclosed in the other minerals. The magnetite is titaniferous as shown by the border of leucoxene which often surrounds the crystals. The cryptocrystalline groundmass is coloured grey to brownish white, and consists of fibrous radiating aggregates mixed with glass. Of the secondary minerals resulting from decomposition, and occurring in amygdules and cracks, calcite is the most plentiful. Analcite and natrolite also occur.

The rock from Engalm described by Pichler as a melaphyre or porphyrite was found to be almost identical with the Ehrwald rock, only differing from it in containing less hornblende, and in having suffered more from decomposition.

The author refers these rocks to the augitites; but, as they differ from other augitites by the presence of a rhombic pyroxene, he proposes for the new type the local name Ehrwaldite. G. T. P.

On foreign rock inclusions in some Scandinavian diabases. H. Bäckström (*K. schwed. Akad. d. Wissensch*, September, 1890) shows in the case of several Scandinavian diabases the effects produced by a diabase magma upon fragments of other rocks which it has caught up. The rocks examined were diabases from Stabäk, Salen, Tysaker and Ostö and a proterobase from Sindsen. The author regards the "Augengranit," occurring in the south of Sweden, as the rock from which the included fragments were derived. According to the author's theory, during its eruption the diabase magma has caught up fragments of the granite. Solution and absorption have at once set in with the result that the dark minerals, the mica and hornblende, which offer the least resistance to solution, soon disappeared almost completely without leaving recognisable decomposition products. In the case of the Sindsen rock, however, where the action seems to have been less energetic, slight traces of these constituents were found. The larger crystals of quartz and felspar offered a greater resistance. In the case of the felspars, which are chiefly microcline, the basalt magma attacks the edges, and penetrates by innumerable

fine cracks (produced by temperature changes) into the interior of th crystals or, where the action is more energetic, dissolves out hollow spaces i them. The effect of the magma on the quartz is confined to the exteri of the crystals, whereby irregularly rounded forms have resulted, witho any change taking place in the general appearance of the crystals; th same is the case with the garnet, which is also only attacked on the surfa with formation of a zone of magnetite. The diabase magma in conta with felspar crystals becomes much more acid than the rest, so that a the mineral constituents of the basalt separate out before crystallisatio commences in the fine cracks and spaces dissolved out of the crystals. I the large solution spaces (Lösungsräume) the final consolidation ha chiefly resulted in the formation of lath-shaped crystals of a plagi clase felspar, and quartz in parts showing a micropegmatitic structu with the felspar. The plagioclase is intermediate between oligoclase an andesine: it occurs with parallel orientation throughout the space. Owi to the fact that the magma in the solution spaces was the last to solidif cavities were also produced, which were later filled up with alteratio products, such as calcite and chlorite. The felspar which has crystallise out in the fine cracks is similar to that in the larger spaces, and is i exact crystallographic orientation with the surrounding unaltered micr cline. A peculiar grained appearance (Körnelung) is the result. Su rounding the enclosed felspar crystals there is a zonal intergrowth plagioclase and quartz, always in crystallographic orientation with ther In the case of the enclosed quartz crystals, which are much rarer tha the felspars, in the immediate contact zone a beautiful spherulitic stru ture is observed, the spherules consisting of quartz and orthoclase oligoclase. G. T. P.

"*Contact-metamorphism*" *in mica-schists.*—On Schneekoppe, the highe mountain of the Riesengebirge, the mica-schists of the district are seen junction with a biotite-granite which breaks through them, and in th neighbourhood of the granite they are found to exhibit interesting ph nomena of metamorphism, evidently due to the intrusion of the massi rock. The normal mica-schists are composed of quartz and a silver white to pale brownish potash-mica, with accessory minerals, includi garnets up to the size of a pea and black needles of tourmaline. Th quartz forms lenticular patches, which the mica wraps in the form films, so that on a fracture along the schistosity the former miner is not shown at all. The garnet has only very imperfect crystal for (110).

In the metamorphosed mica-schist andalusite is abundantly developed well-built prisms several centimeters long. It has a reddish-grey our, and encloses many small flakes of mica. The mica of the rock now mostly a dark magnesian variety, and instead of filmy layers rms little isolated flakes. The quartz too occurs in isolated ains rather than in lenticles, and the rock as a whole shows in cross- tions a much less marked schistose structure than before. Instead of imperfect garnets occur lustrous blood-red crystals with good forms 0) and (211) together or more rarely by themselves, the faces of the ter form being striated. An analysis of the crystals gave :—

SiO_2	Al_2O_3	Fe_2O_3	FeO	MnO	CaO	Total
34·54	22·26	7·09	32·74	2·32	1·33	100·28

The garnets in the normal schists are too full of inclusions to give terial for analysis. (W. Müller in *Zeits. d. deuts. geol. Ges.*, Vol. XLIII. p. 730.) A. H.

The Vesuvian Lavas and Ashes of 1891.—R. V. Matteucci describes the ducts of the eruption of Vesuvius commencing June 1891 (*Atti d. R. ad. Sci. fis. e mat. Napoli*, Vol. V.). These consist of both lavas and es. The lavas of the several flows have all the same general type, d, like the other Vesuvian lavas, are leucite-tephrites or (if olivine ers) leucite-basanites. Leucite and augite occur each in two genera- ns, the large crystals imparting a marked porphyritic character to the k. The groundmass has in sections an iron-grey to violet-tinted pearance, and consists of a semi-opaque glassy base enclosing with a xional arrangement countless microlites of the same minerals as those bedded in the ground. The leucite is the dominant constituent of the k, the larger crystals showing polygonal outlines with some corrosion, d containing inclusions of glass and augite with zonal arrangement, re rarely fluid-pores with bubbles. The crystals have the polysynthetic inning parallel to (201), described by Klein. The augite is green, with nes of growth marked by different colouring, and occurs in good ystals, those of the earlier generation being however corroded. The clusions are of magnetite and rarely fluid with bubbles. Plagioclase curs, but apparently not sanidine. Olivine and nepheline may be esent, but were not found : [in the Vesuvian lavas in general they are ually but not constantly present]. Limonite and micaceous hæmatite e found in the vesicles of the lava ; magnetite and probably ilmenite are nstituents of the groundmass.

The ashes become lighter in colour with distance from their sourc owing to smaller proportions of the darker and heavier constituen (augite, magnetite, etc.). Much of the material, however, consists minute fragments of greenish glass. About 1·75 per cent. dissolved out water and was found to consist of sulphates of the alkalies, chlorides the alkali metals and iron, and carbonates of the alkalies, and perha lime, besides free sulphuric and hydrochloric acids. These acids al occurred impregnating the lavas themselves. A. H.

On the Barium Sulphate from Perkins' Mill, Templeton, Quebec.- Edward S. Dana. *American Journal of Science*, Vol. XXXIX. 1890.

A Lacroix (*Comptes Rendus*, CVIII, 1126) described under the nar of *Michel-levyte*, a mineral having the same composition as Baryt $BaSO_4$, but, as he believed, crystallising in the monoclinic system. T locality of this mineral is that from which Prof. Dana obtained the spe mens of barium sulphate referred to in this paper; hence there is litt doubt that the *Michel-levyte* of Lacroix and the barium sulphate of Da are identical. The examination of the specimens by Prof. Dana shows th the mineral is rhombic in form and he concludes by saying that he "regar it as proved beyond doubt, for the specimens which he has had in ha from Perkins' Mill, that they are normal barite; and that the existence a monoclinic form of barium sulphate among specimens from that locali is extremely doubtful." C. J. W.

Additional notes on the Tyrolite from Utah.—W. F. Hillebrand and S. Dana. *American Journal of Science*, Vol. XXXIX. April 1890.

Dr. Hillebrand collected pure specimens of the mineral from t Mammoth mine in September 1888. His analysis gave :—

CuO	45·08
CaO	6·78
As_2O_5	28·52
H_2O	17·21
SO_3	2·23
Fe_2O_3	0·08
Insoluble	0·16
	100·06

It had been supposed from the previous examination that the S belonged to admixed gypsum, but Dr. Hillebrand concludes that the S

an essential constituent of the mineral, "it therefore appears necesary to consider the latter (SO_3) as a proper constituent of the mineral, ut the construction of a probable formula is not rendered thereby less diffilt and will not now be attempted."

A remark is made as to the loss in weight of the mineral when placed a desiccator over sulphuric acid. It appears that one gram of the ineral kept losing weight for 283 hours and a steady loss of 3/10 of a illigram per day occurred for six weeks.

Prof. E. S. Dana describes the crystalline form of the mineral as llows :—"The crystals are in thin tables or scales flattened parallel the basal plane of cleavage, and they are united by one edge so as to rm radiating fan-shaped groups having a rounded and deeply striated terior. Occasionally minute isolated crystals can be observed. These re seen under the microscope to be bounded by the pinacoidal edges arallel to which extinction takes place; further, the bisectrix is found to sensibly normal to the tabular plane of cleavage, so that they can be ferred to the orthorhombic system with little question. Besides the nacoids the crystals are bounded by two prisms 110 and 120, the rmer having a normal angle in front of 86°, while the latter is inclined 010 at an angle of 28°. From the first angle we calculate—

$$a : b = 0{\cdot}9325 : 1 ;\ 120 \wedge 010 = 28° 12'$$

o planes were observed which could fix the length of the vertical axis. he crystals are elongated parallel to the macro-axis and the optic axes e in the brachydiagonal section, the bisectrix being normal to the base; e character of the double refraction is negative, and the axial angle rge."

Comparative observations on artificial and natural minerals.—A. zzruni, *Zeitschrift für Krystallographie*, XVIII. p. 44, 1890.

1. Sublimed Hæmatite. The author gives measurements of crystals artificially formed hæmatite from alkali works in Hruschau and from kali works at Schönebeck, Elbe, together with measurements of the same ineral in the natural form from Vesuvius (San Sebastiano).

The crystals from Hruschau are formed in the saltcake furnace where e clay lining is cracked. Herr von Miller, the proprietor of the works, nsiders the production of the crystals due to the fact that the sulphuric id used contains iron; and that this acid coming in contact with salt ves rise to $FeCl_3$, which is converted by the oxygen of the air or by eam into Fe_2O_3.

Another view might also be taken, viz. that the crystals result from a decomposition of the iron sulphate contained in the sulphuric aci In order to form a conclusion on the subject some of the clay lining wa finely powdered and boiled in distilled water, and afterwards filtered, th feebly acid filtrate gave equally strong indications of sulphuric acid as chlorine. A similar experiment, made with lava from San Sebastian containing hæmatite, gave reaction for chlorine alone.

The crystals from Hruschau show the form $\{\bar{2}\bar{1}32\}$, but want the for $\{224\bar{3}\}$; the one form, so to speak, replacing the other. The crysta from San Sebastiano have both forms.

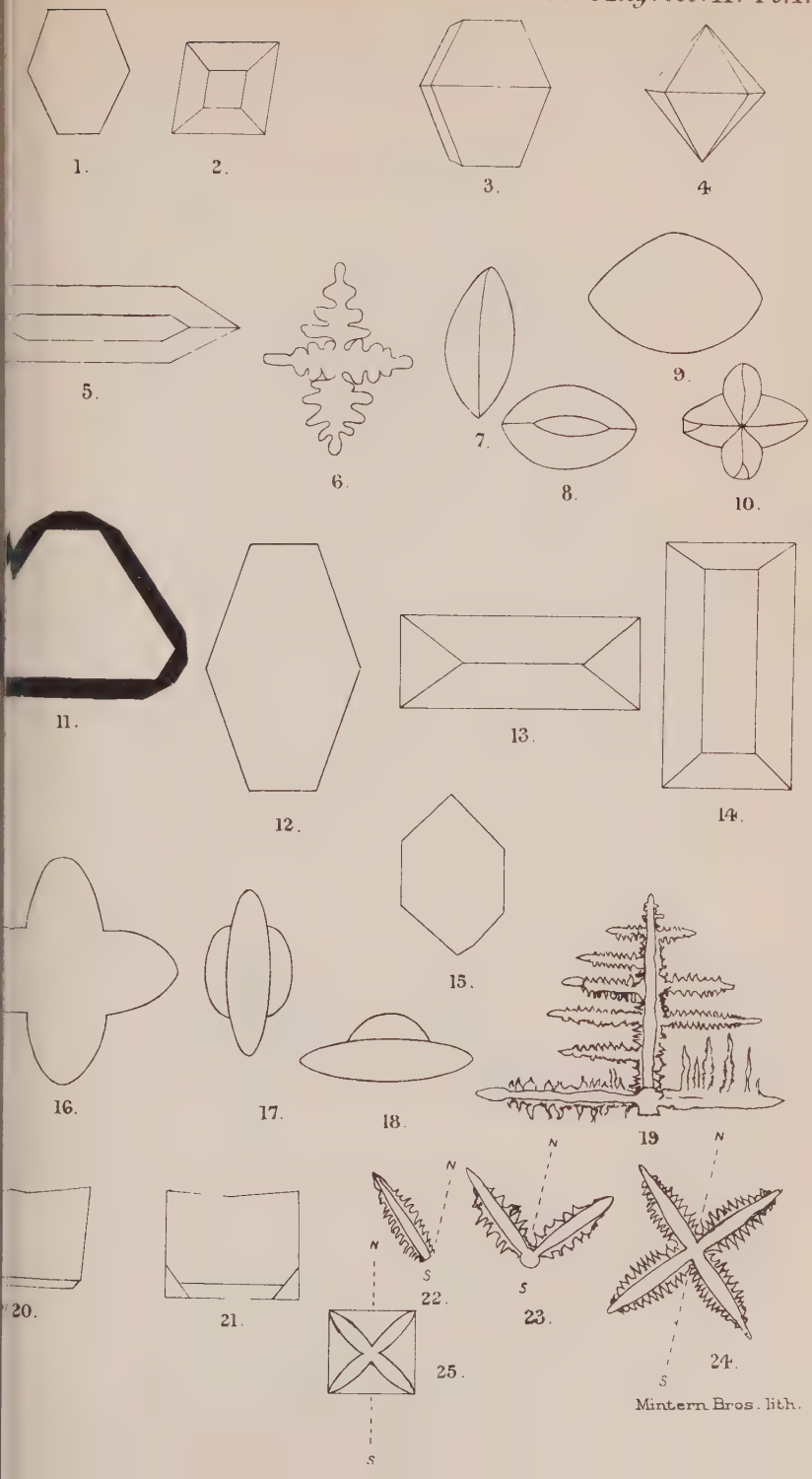
The author observed two new forms, probably $\{\bar{4}\bar{2}61\}$ and $\{\bar{8}\ \bar{6}\ 14\ 1\}$ but the measurements do not agree closely with the calculated angles.

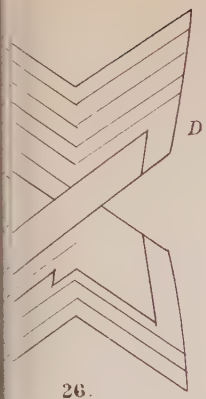
2. Sublimed Senarmontite and Valentinite. The author has not m with any recorded instance of these minerals produced by sublimatio They are apparently formed by the oxidation of antimonite, but und what conditions the one or the other of the two modifications of Sb_2 may be produced is not clear. From inquiries made of the manager some antimony works, it would seem that both modifications are pr duced in roasting antimonite, both needles and octahedra being produce at the same time. Specimens were examined with the followi results :—

The Senarmontite is in sharp octahedral crystals of adamantine lust 1–2 mm. in diameter, presenting the combination $\{111\}$ $\{110\}$. T form $\{110\}$, so far as the author knows, has not been observed either natural or artificial senarmontite. These crystals have very smooth a brilliant faces.

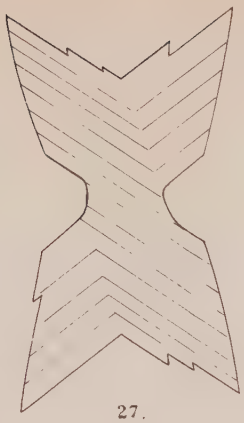
The Valentinite is in transparent, strongly refracting, or in flat wh needles, at the most 0·5 mm. thick, and about 2 cm. long. These de cate crystals show a cleavage at the broken ends parallel to their lengt Good measurements could not be obtained, but the mean of 8 obser tions gave $(110) : (1\bar{1}0) = 42° 59'$.

3. Cuprite formed at a high temperature. The crystals examined from zinc works, and were found on breaking up an oven used for roa ing lead ore containing copper. They present a combination of $\{10($ $\{111\}$, $\{110\}$, $\{h0l\}$; lustre, strongly adamantine; colour, deep che red; transparent. No octahedral cleavage was observed.

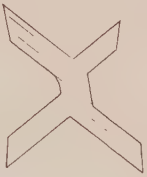

1.
2.
3.
4
5.
6.
7.
8.
9.
10.
11.
12.
13.
14.
15.
16.
17.
18.
19
20.
21.
22.
23.
24.
25.
N
S
Mintern Bros. lith.



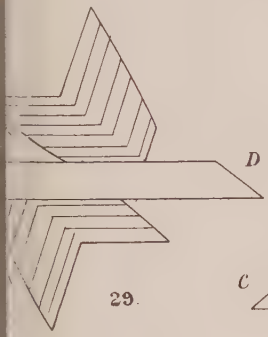
26.



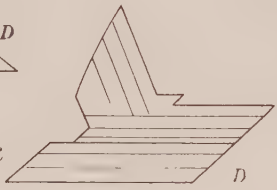
27.



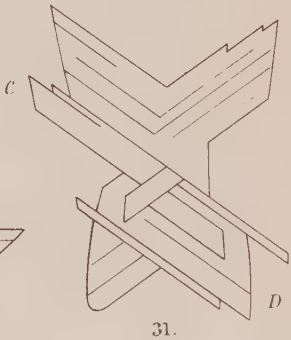
28.



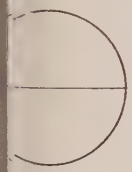
29.



30.

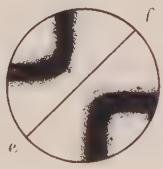


31.



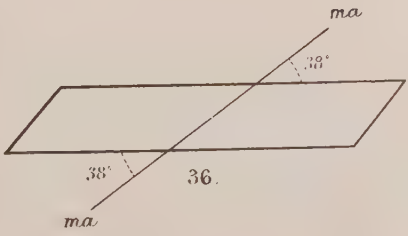
32.

33



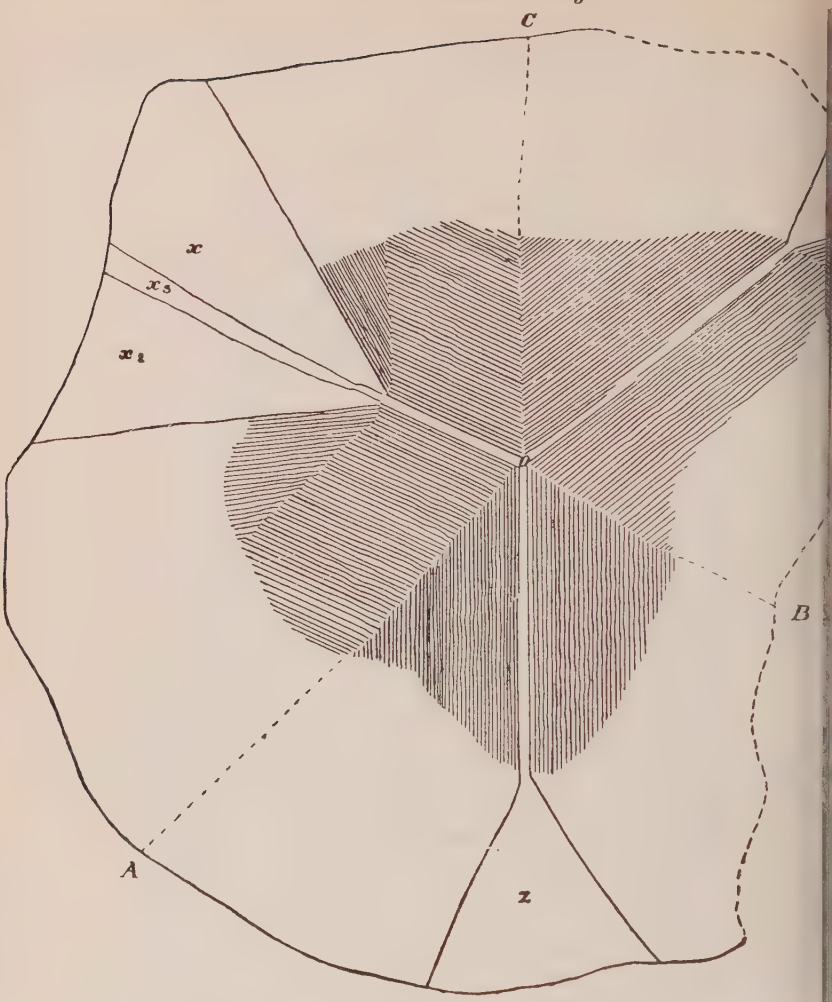
34.

35.



36.

Minnern Bros. lith.



Key to the Section of Quartz represented in opposite Plate.

The wedges marked *x*, *y*, *z* are of a pale yellow colour, as are al the three plates proceeding from these wedges and meeting in the cen of the crystal *O*. This yellow quartz is stable quartz, and shows no si of lamellar structure. The wedge *y* exhibits left-handed circular polari tion, while the wedge z shows right-handed polarisation. In the la wedge *x* we have both right- and left-handed quartz, *x* being right-hand and x_2 left-handed; the plane of junction of these two varieties of qua is evidently not normal to the plane passing through the lateral axes, a where the one variety overlaps the other (x_3) we have beautiful Air spirals exhibited in convergent polarised light.

Section of a Quartz (Amethyst) Crystal (magnified $2\frac{1}{2}$ times), as seen between crossed nicols and photographed in mono-chromatic (green) light.

The section shows very clearly the distinction between the stable (non-
nellar) quartz, and the unstable (lamellar) quartz.

While the yellow parts of the crystal exhibit the ordinary circular
larisation (with Airy's spirals locally) characteristic of quartz crystals,
remaining sectors of the crystal (which are divided along the lines *OA*,
OB, *OC*, where lamellæ of opposite character meet) exhibit no trace
atever of circular polarisation. In the centre, where the lamellæ are
their normal position, the section gives the interference-figures of an
iaxial crystal, but nearer to the sides of the crystal biaxial interference-
ures are given, and these become greatly disturbed where the distur-
ace in the position of the lamellæ is excessive.

CONTENTS OF No. 46.

Notes on the Micro-chemical Analysis of Rock-making Minerals. By Lieutenant General C. A. McMahon, F.G.S. .....

Additional Note on the Lamellar Structure of Quartz-Crystals, and the methods by which it is developed. By Professor John W. Judd, F.R.S., V.P.G.S. .....

On some examples of Cone-in-Cone Structure. By Professor Grenville A. J. Cole, F.G.S. .....

Note on a Crystal of Tourmaline. By W. J. Lewis, M.A., F.C.S., Professor of Mineralogy in the University of Cambridge.....

Note on a peculiar occurrence of Galena. By J. Stuart Thomson .....

On Geikielite, a New Mineral from Ceylon. By A. Dick. Communicated by J. J. H. Teall, F.R.S. .....

On Baddeleyite (native zirconia), a new Mineral, from Rakwana, Ceylon. By L. Fletcher, M.A., F.R.S. ....

Obituary.—Thomas Davies, F.G.S.....

Reviews .....

Abstracts .....

ORIGINALLY PRINTED IN GREAT BRITAIN BY MESSRS. WILLIAMS AND STRAHAN, LONDON. REPRINTED OFFSET LITHO BY BIDDLES LTD., THE CITY PRESS, GUILDFORD, SURREY.